2010 Wind Technologies Market Report

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Lawrence Berkeley National Laboratory

Report Summary

June 2011

Presentation Overview

- Introduction to 2010 edition of U.S. wind energy market report
- Wind installation trends
- Wind industry trends
- Price, cost, and performance trends
  - Power sales prices
  - Installed wind project costs
  - Wind turbine transaction prices
  - Wind project performance
  - O&M cost trends
- Policy and market drivers
- Future outlook

2010 Wind Technologies Market Report

Purpose, Scope, and Data:

- With a focus on 2010, summarize trends in the U.S. wind power market, including information on wind installations, industry developments, power sales prices, project costs, performance, O&M costs, policy/market trends
- Scope primarily includes wind turbines over 100 kW in size
- Data sources include AWEA, EIA, FERC, SEC, etc. *(see full report)*

Report Authors:

- Primary authors: Ryan Wiser and Mark Bolinger, Berkeley Lab
- Contributions from others at Berkeley Lab, Exeter Assoc., NREL, Energetics

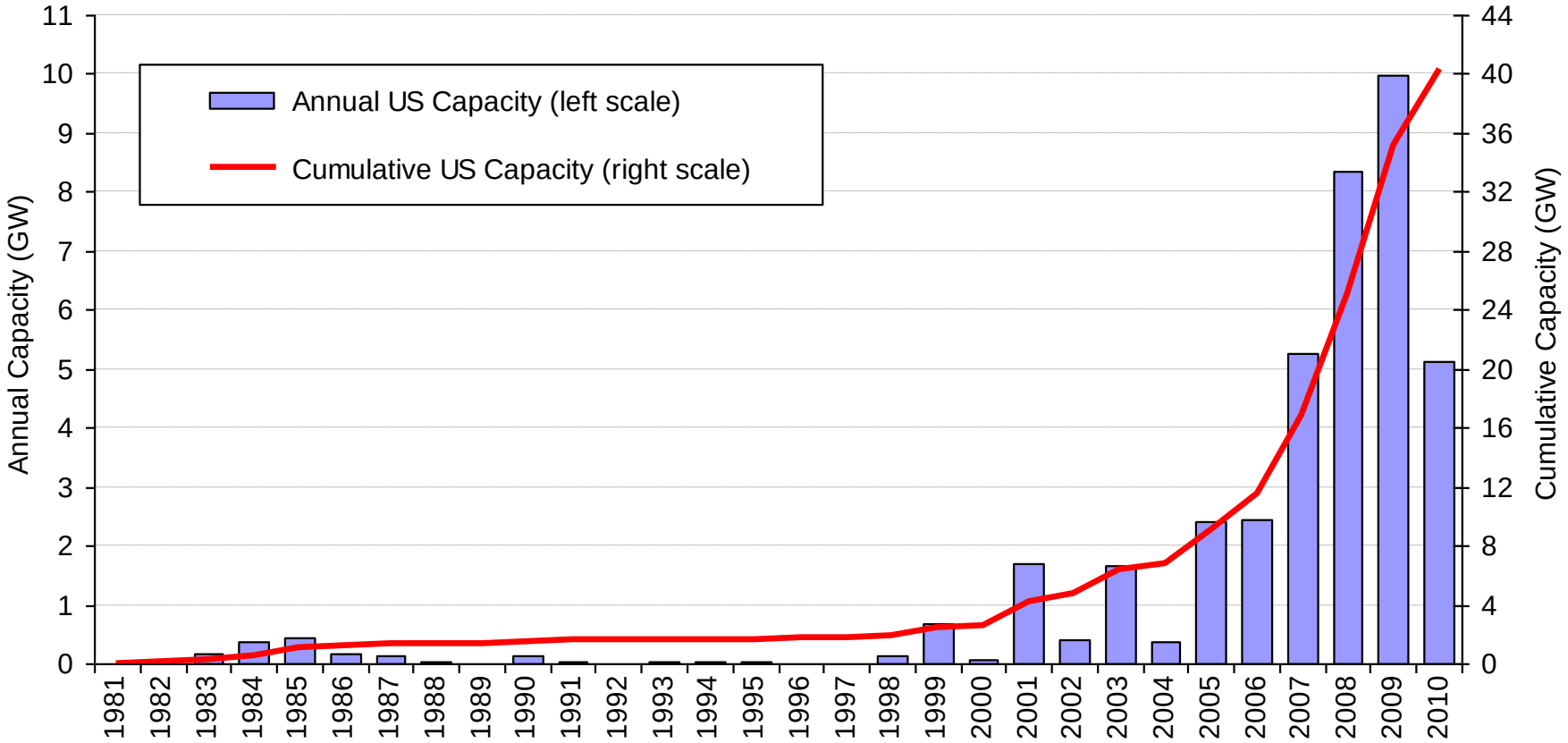
Available at: http://windandwater.energy.gov/

New to the 2010 Edition of the Report

- More in-depth summary of developments in offshore wind energy
- Expanded discussion of wind power curtailment in various regions of the country
- Further information on domestic nacelle assembly capacity

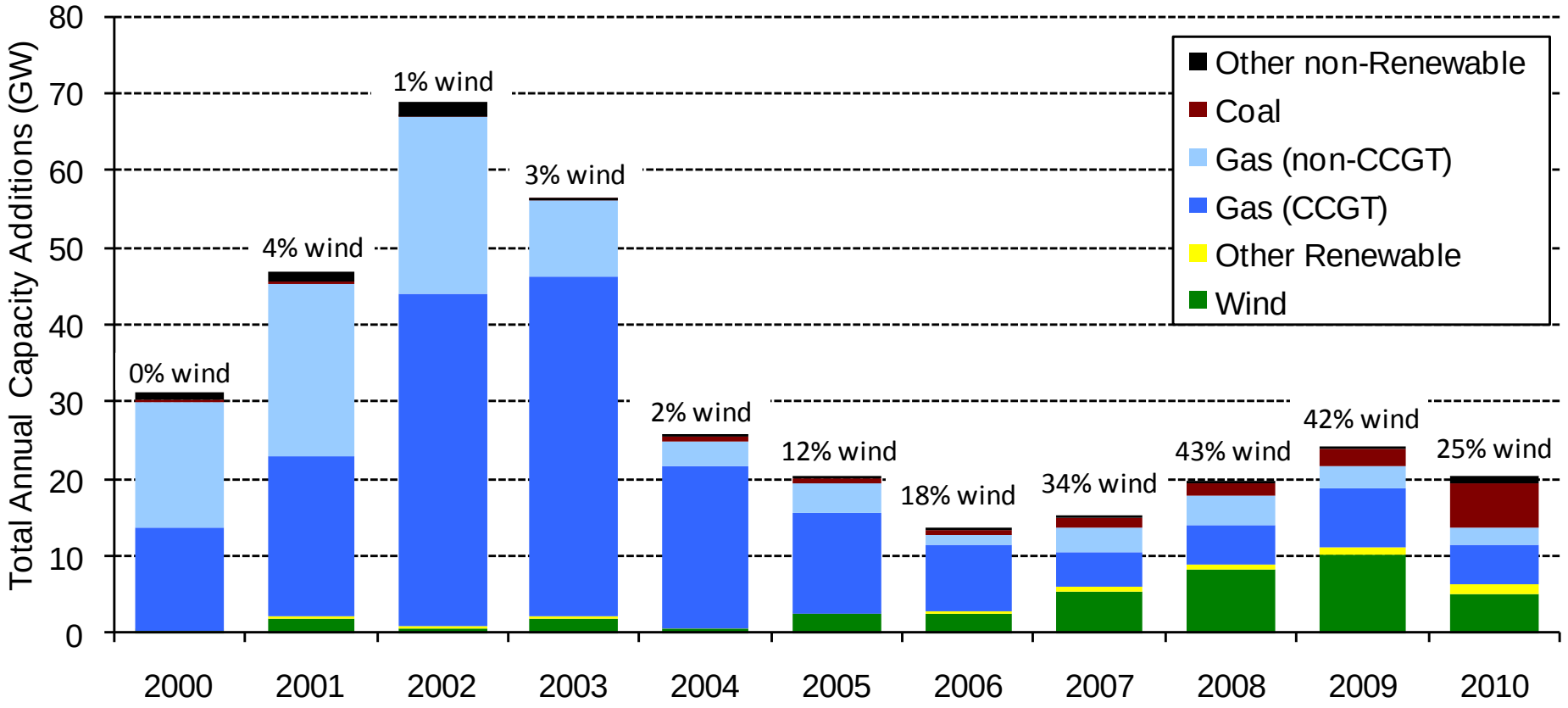
Installation Trends

U.S. Wind Power Additions Slowed in 2010



- 5.1 GW of wind power added in 2010 in US, $11 billion in project investment
- Cumulative wind power capacity up by 15%, bringing total to >40 GW
- Factors slowing growth: (1) delayed impact of financial crisis; (2) low natural gas / wholesale electricity prices; (3) slumping overall demand for energy

Wind Power Comprised 25% of Electric Generating Capacity Additions in 2010



- But 25% in 2010 represents wind's lowest share since 18% in 2006
- Wind slips to 3rd-largest resource added in 2010, after gas and coal

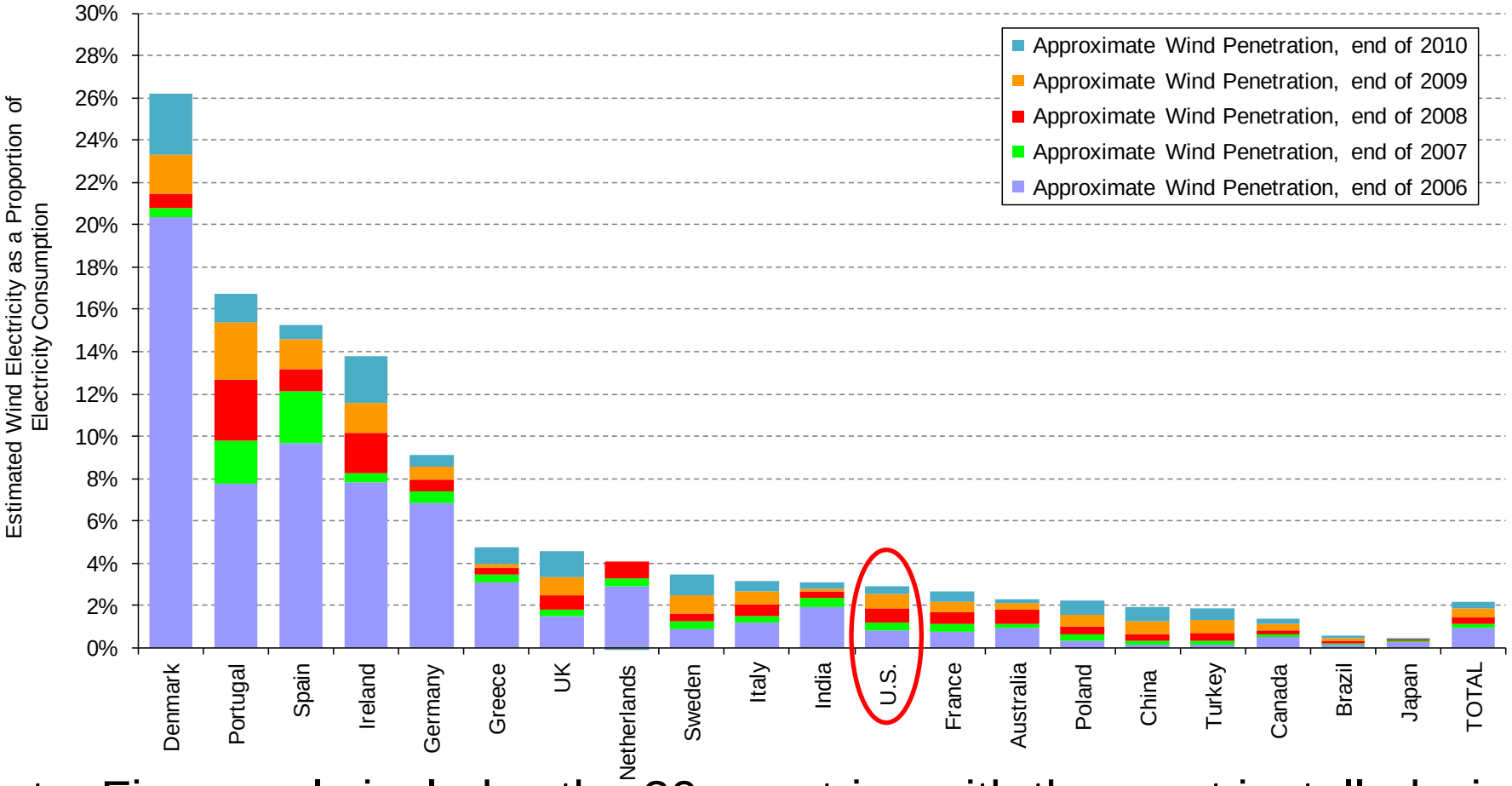
China Was 1st and the U.S. Was 2nd in Both New and Cumulative Wind Power Capacity

Annual Capacity (2010, MW)		Cumulative Capacity (end of 2010, MW)	
China	18,928	China	44,781
U.S.	**5,113**	**U.S.**	**40,267**
India	2,139	Germany	27,364
Germany	1,551	Spain	20,300
U.K.	1,522	India	12,966
Spain	1,516	France	5,961
France	1,186	U.K.	5,862
Italy	948	Italy	5,793
Canada	690	Canada	4,011
Sweden	604	Portugal	3,837
Rest of World	5,205	*Rest of World*	28,371
TOTAL	**39,402**	**TOTAL**	**199,513**

Source: BTM Consult; AWEA project database for U.S. capacity

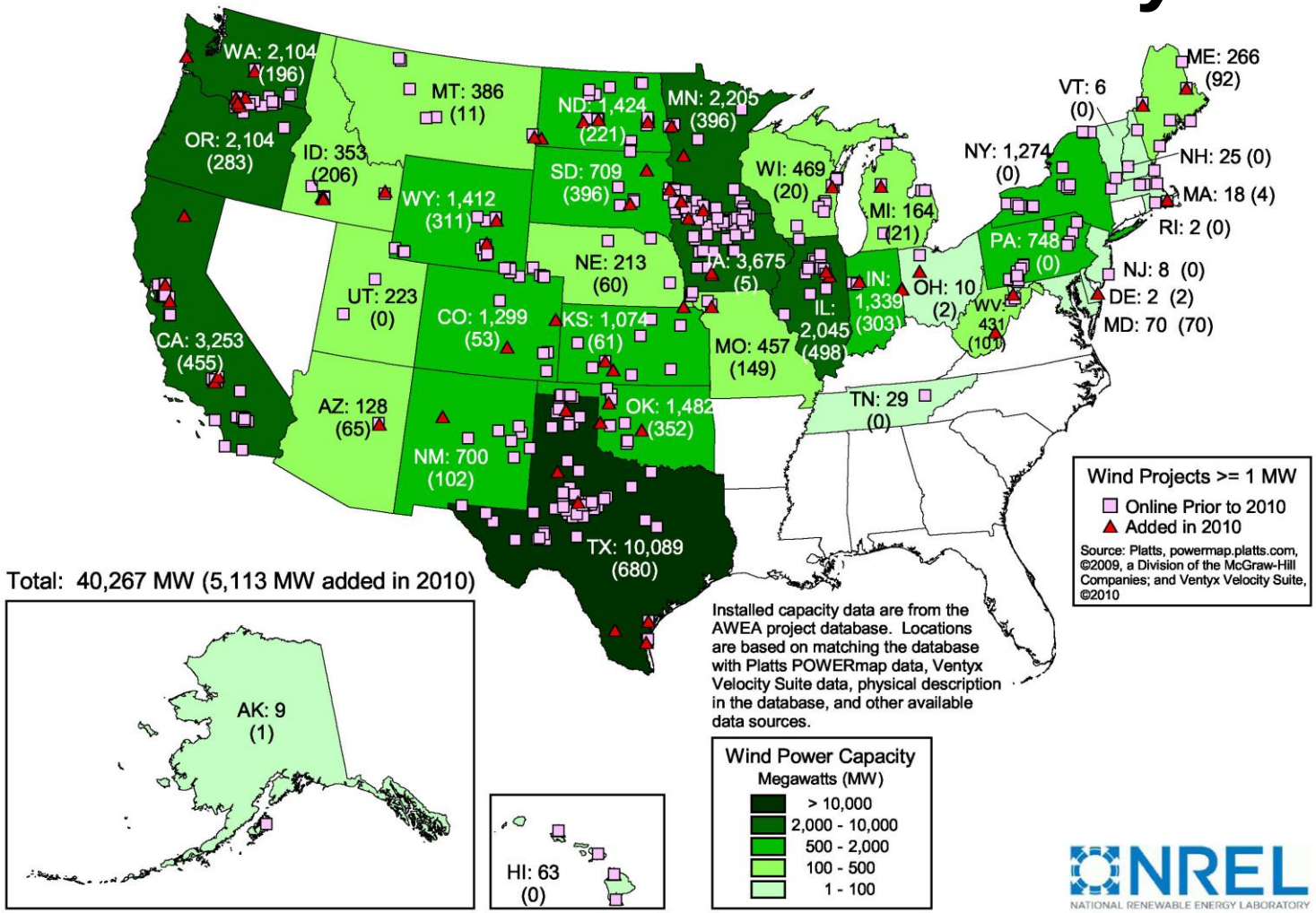
- Global wind power capacity additions in 2010 similar to 2009 levels
- US additions = 13% of global additions in 2010, down from 26% in 2009

U.S. Lagging Other Countries in Wind As a Percentage of Electricity Consumption



Note: Figure only includes the 20 countries with the most installed wind power capacity at the end of 2010

Geographic Spread of Wind Power Projects in the United States Is Reasonably Broad



Texas Leads Capacity, But Not Penetration

Capacity (MW)			
Annual (2010)		Cumulative (end of 2010)	
Texas	680	Texas	10,089
Illinois	498	Iowa	3,675
California	455	California	3,253
South Dakota	396	Minnesota	2,205
Minnesota	396	Washington	2,104
Oklahoma	352	Oregon	2,104
Wyoming	311	Illinois	2,045
Indiana	303	Oklahoma	1,482
Oregon	283	North Dakota	1,424
North Dakota	221	Wyoming	1,412
Idaho	206	Indiana	1,339
Washington	196	Colorado	1,299
Missouri	149	New York	1,274
New Mexico	102	Kansas	1,074
West Virginia	101	Pennsylvania	748
Maine	92	South Dakota	709
Maryland	70	New Mexico	700
Arizona	65	Wisconsin	469
Kansas	61	Missouri	457
Nebraska	60	West Virginia	431
Rest of U.S.	118	*Rest of U.S.*	1,974
TOTAL	**5,113**	**TOTAL**	**40,267**

Percentage of In-State Generation			
Actual (2010)*		Estimated (end of 2010)**	
Iowa	15.4%	South Dakota	23.2%
North Dakota	12.0%	Iowa	16.9%
Minnesota	9.7%	North Dakota	13.5%
South Dakota	8.3%	Minnesota	12.3%
Kansas	7.1%	Oregon	9.8%
Oregon	7.1%	Wyoming	8.2%
Wyoming	6.7%	Colorado	7.8%
Colorado	6.6%	Kansas	7.6%
Texas	6.4%	Idaho	7.3%
Oklahoma	5.1%	Oklahoma	6.9%
New Mexico	5.0%	Texas	6.7%
Washington	4.6%	New Mexico	6.0%
Idaho	4.0%	Washington	5.2%
California	3.3%	Maine	4.4%
Montana	3.1%	Montana	3.9%
Maine	2.9%	California	3.9%
Indiana	2.4%	Indiana	3.0%
Hawaii	2.3%	Illinois	2.8%
Illinois	2.2%	Hawaii	2.3%
New York	2.0%	New York	2.0%
Rest of U.S.	0.3%	*Rest of U.S.*	0.3%
TOTAL	**2.3%**	**TOTAL**	**2.6%**

* Based on 2010 wind and total generation by state from EIA's *Electric Power Monthly*.

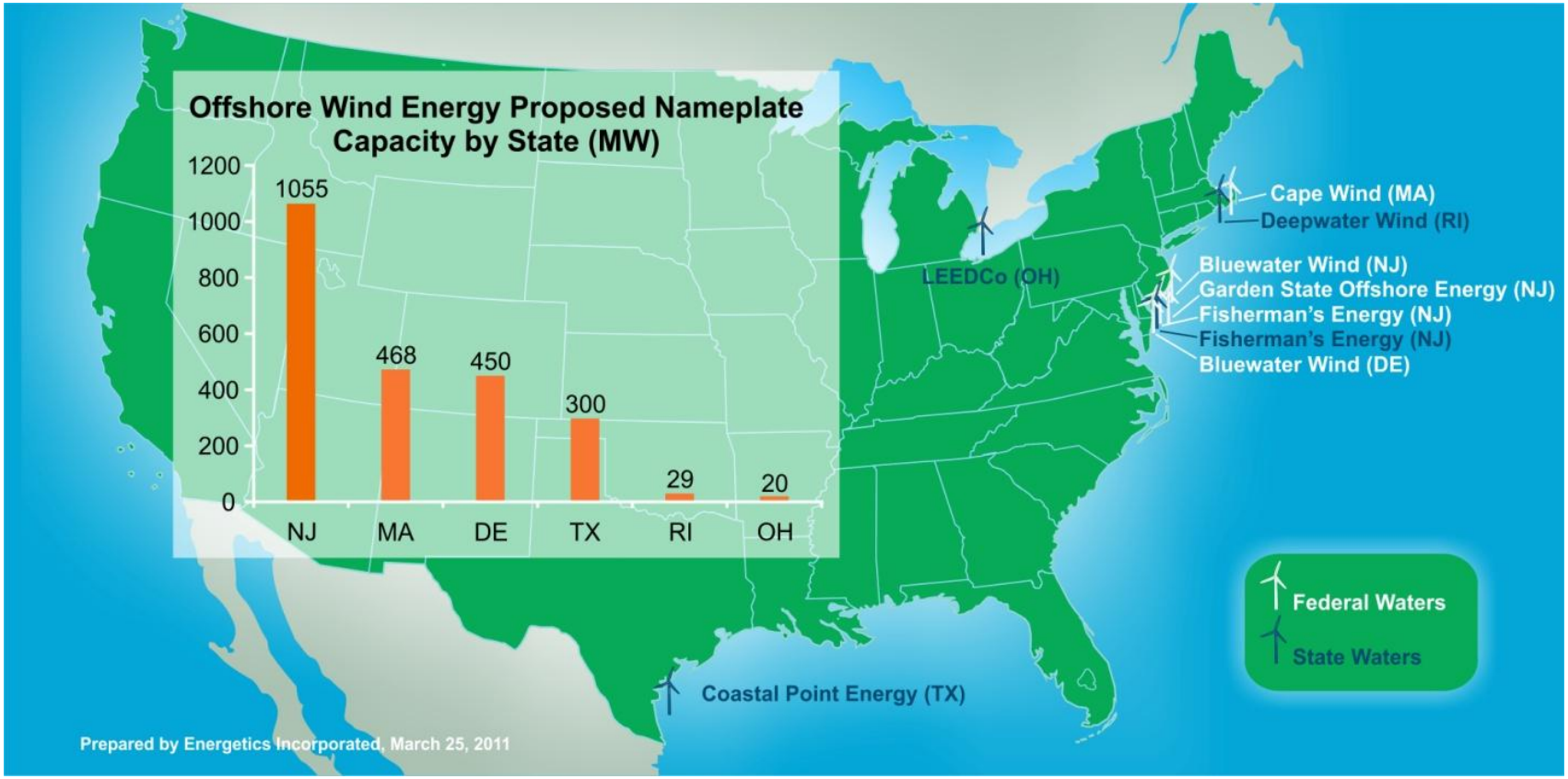
** Based on a projection of wind electricity generation from end-of-2010 wind power capacity, divided by total in-state electricity generation in 2010.

Source: AWEA project database, EIA, Berkeley Lab estimates

At end of 2010:

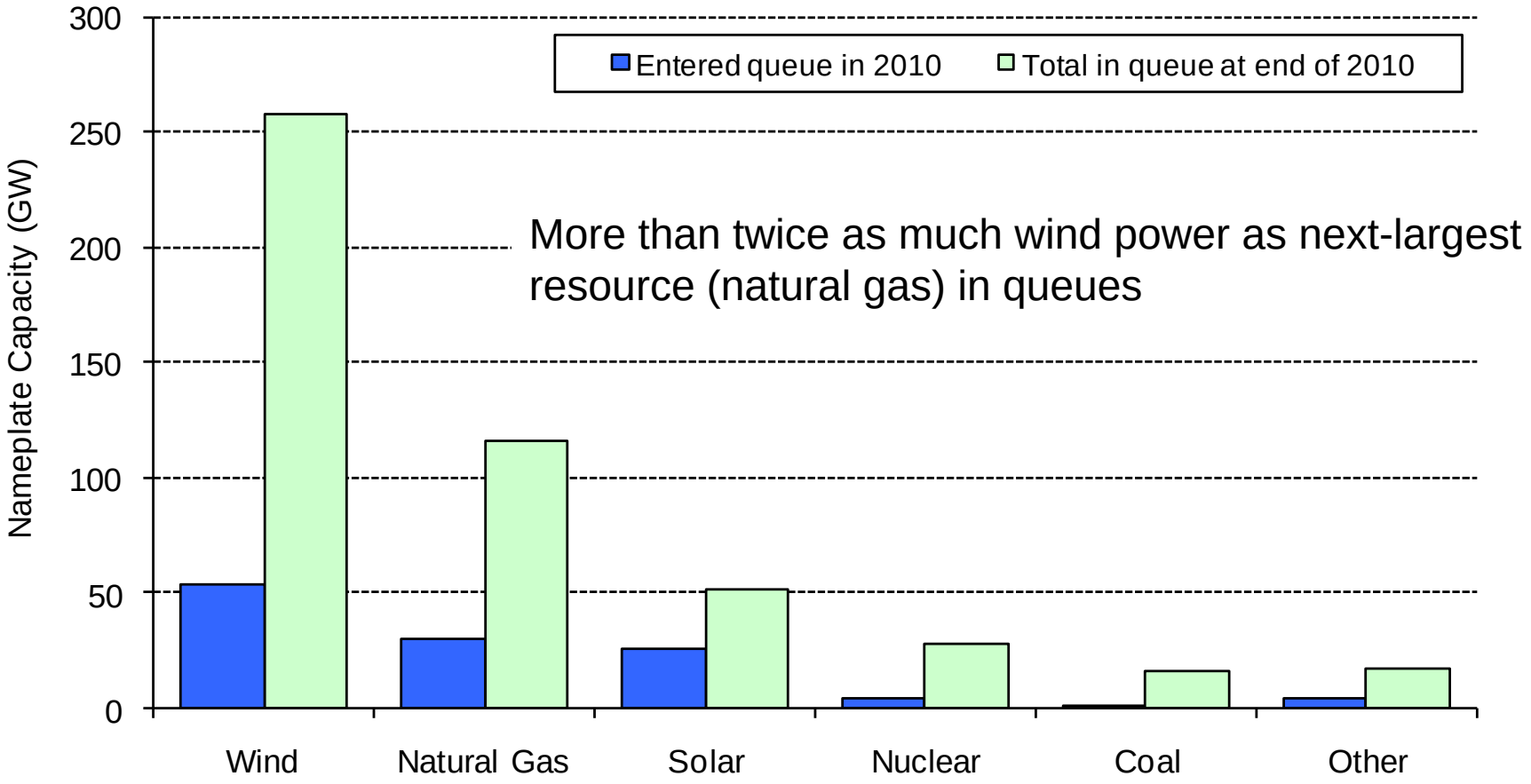
- 17 states had >500 MW of wind capacity (7 had >2000 MW)
- 4 states had the ability to provide >10% of total in-state generation from wind (13 states >5%)

No Offshore Projects Have Been Built in the U.S., But 9 Projects Have Advanced Significantly in Permitting/Development



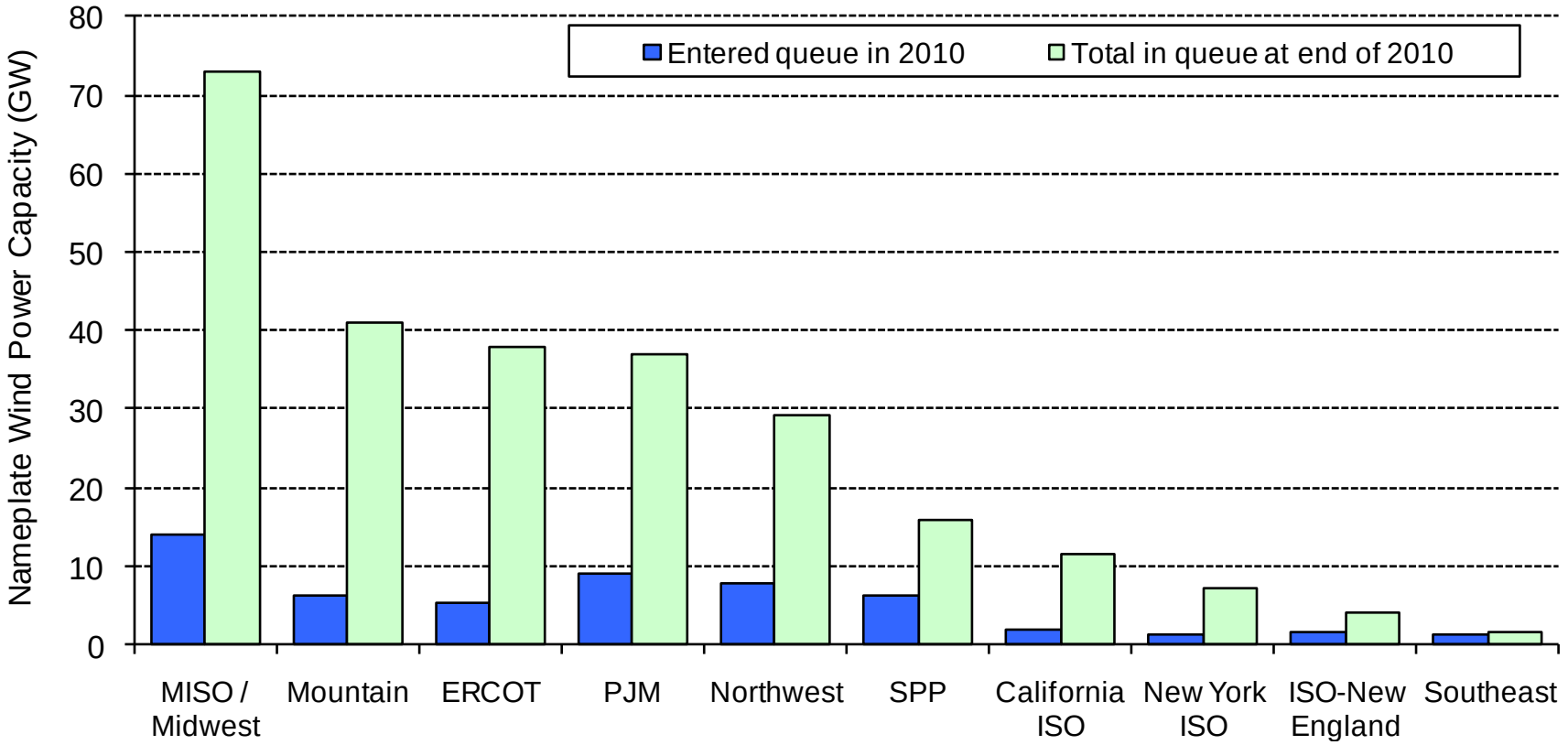
- Three of these projects have signed power purchase agreements

Roughly 260 GW of Wind Power Capacity in Transmission Interconnection Queues



Not all of this capacity will be built….

>90% Planned for Midwest, Mountain, Texas, PJM, Northwest, and Southwest Power Pool Regions

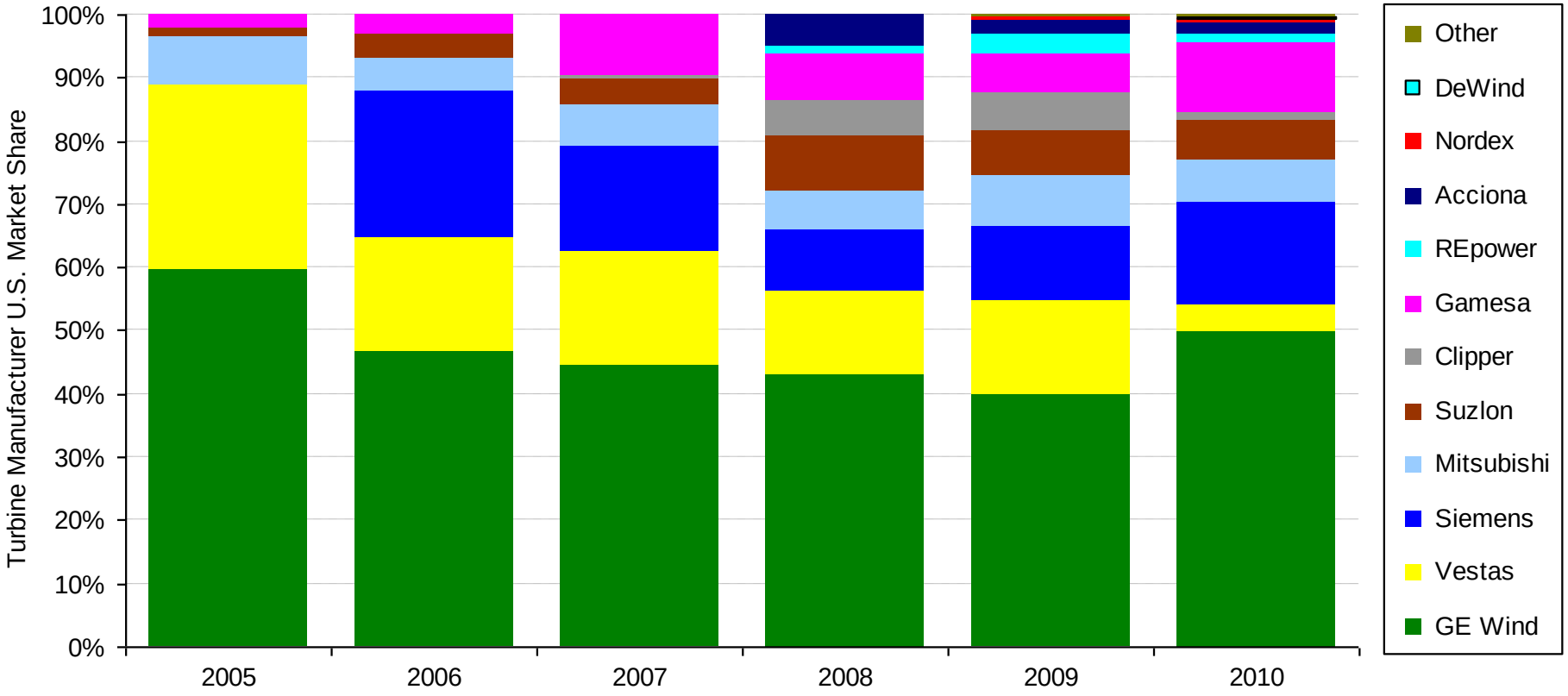


Not all of this capacity will be built….

Industry Trends

GE Remained the Top Turbine Vendor in the U.S. Market

(and increased its market share)

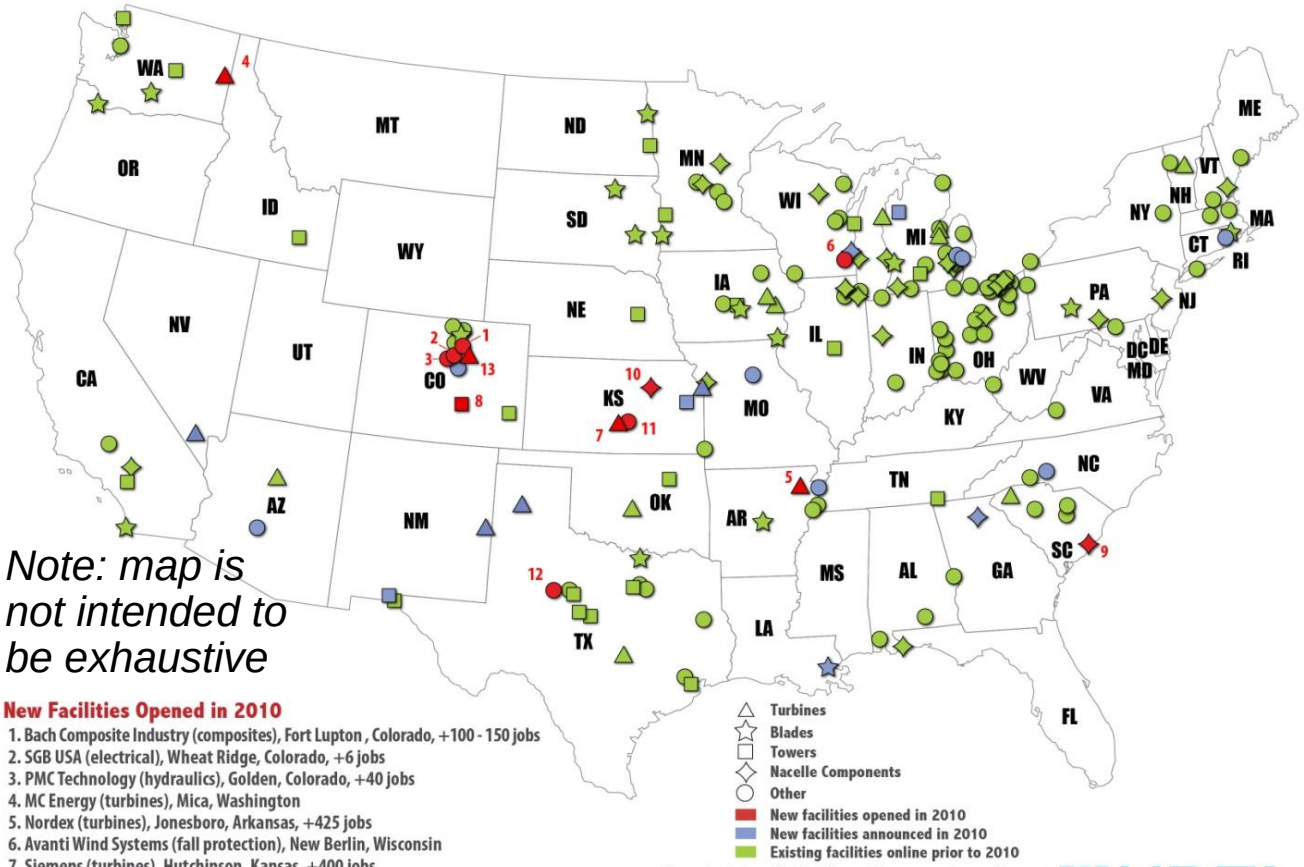


Virtually All Turbine Vendors Active in the U.S. Market Saw MW Declines in 2010

Manufacturer	Turbine Installations (MW)					
	2005	2006	2007	2008	2009	2010
GE Wind	1,433	1,146	2,342	3,585	3,995	2,543
Siemens	0	573	863	791	1,162	828
Gamesa	50	50	494	616	600	564
Mitsubishi	190	128	356	516	814	350
Suzlon	25	92	197	736	702	312
Vestas	700	463	948	1,120	1,488	221
Acciona	0	0	0	410	204	99
Clipper	3	0	48	470	605	70
REPower	0	0	0	94	330	68
Nordex	0	0	3	0	63	20
DeWind	0	0	0	2	6	20
Other	2	2	0	10	25	17
TOTAL	**2,402**	**2,454**	**5,249**	**8,350**	**9,993**	**5,113**

- Southeast Asian turbine vendors continue to eye the U.S. market; no Chinese installations in 2010, but three 2.5 MW Samsung turbines were installed in Texas

Despite Slow Economy, U.S. Wind Turbine Manufacturing Has Grown



Note: map is not intended to be exhaustive

New Facilities Opened in 2010

1. Bach Composite Industry (composites), Fort Lupton , Colorado, +100 - 150 jobs
2. SGB USA (electrical), Wheat Ridge, Colorado, +6 jobs
3. PMC Technology (hydraulics), Golden, Colorado, +40 jobs
4. MC Energy (turbines), Mica, Washington
5. Nordex (turbines), Jonesboro, Arkansas, +425 jobs
6. Avanti Wind Systems (fall protection), New Berlin, Wisconsin
7. Siemens (turbines), Hutchinson, Kansas, +400 jobs
8. Vestas (towers), Pueblo, Colorado, +500 jobs
9. IMO Group (nacelles and components), Charleston, South Carolina, +190 jobs
10. Jupiter Group (nacelle covers and spinners), Junction City , Kansas, +120 jobs
11. Draka (electrical), Hutchinson, Kansas, +20 jobs
12. EMA Electromecanica (electronics), Sweetwater, Texas, +13 jobs
13. Vestas (turbines), Brighton, Colorado, +700 jobs

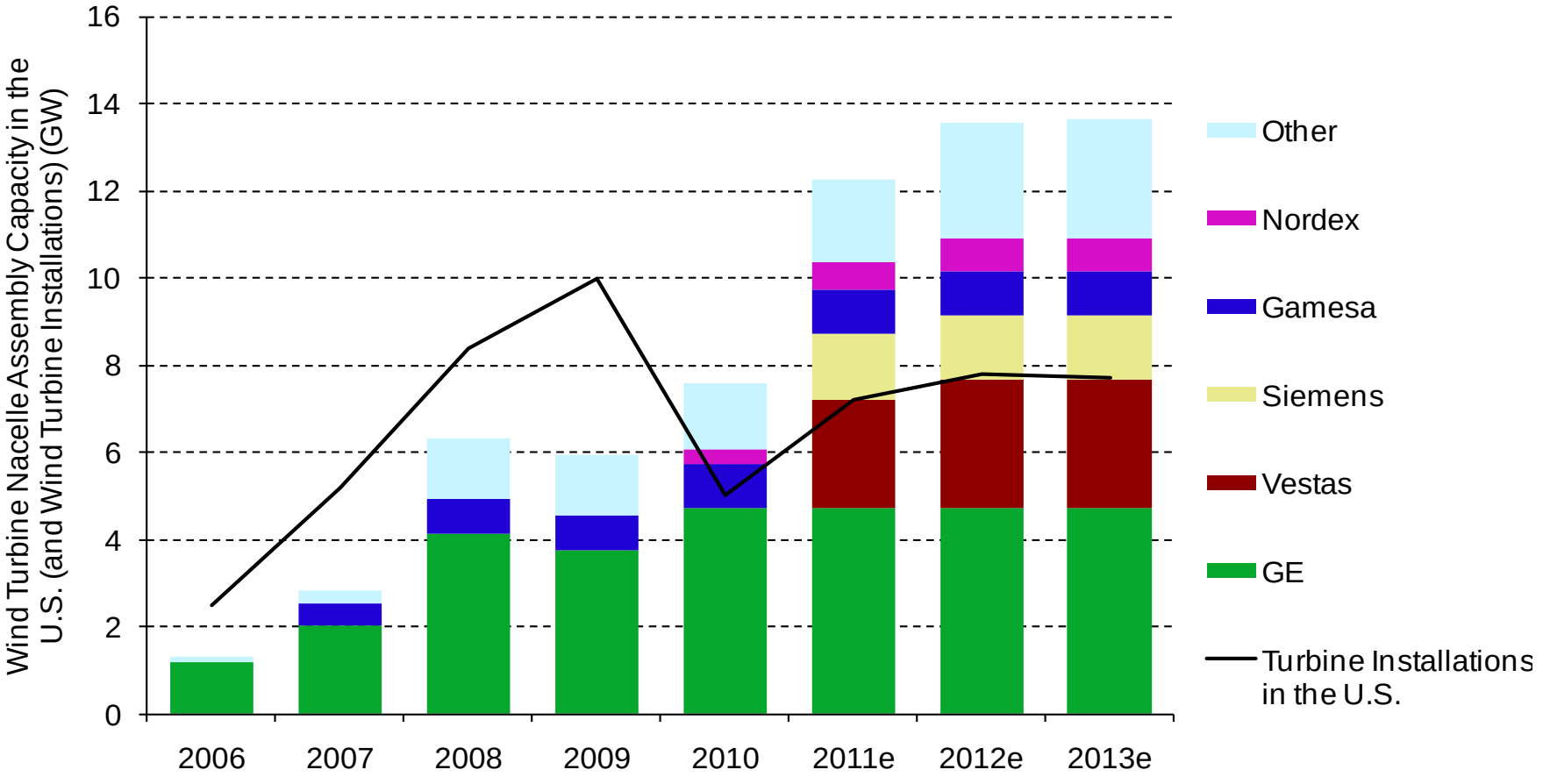
Figure includes wind turbine and component manufacturing facilities, as well as other supply chain facilities, but excludes corporate headquarters and service-oriented facilities. The facilities shown here are not intended to be exhaustive. Those facilities designated as "Turbines" may include turbine and/or nacelle assembly and in some cases the manufacturing of towers, nacelle components, blades or other components.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

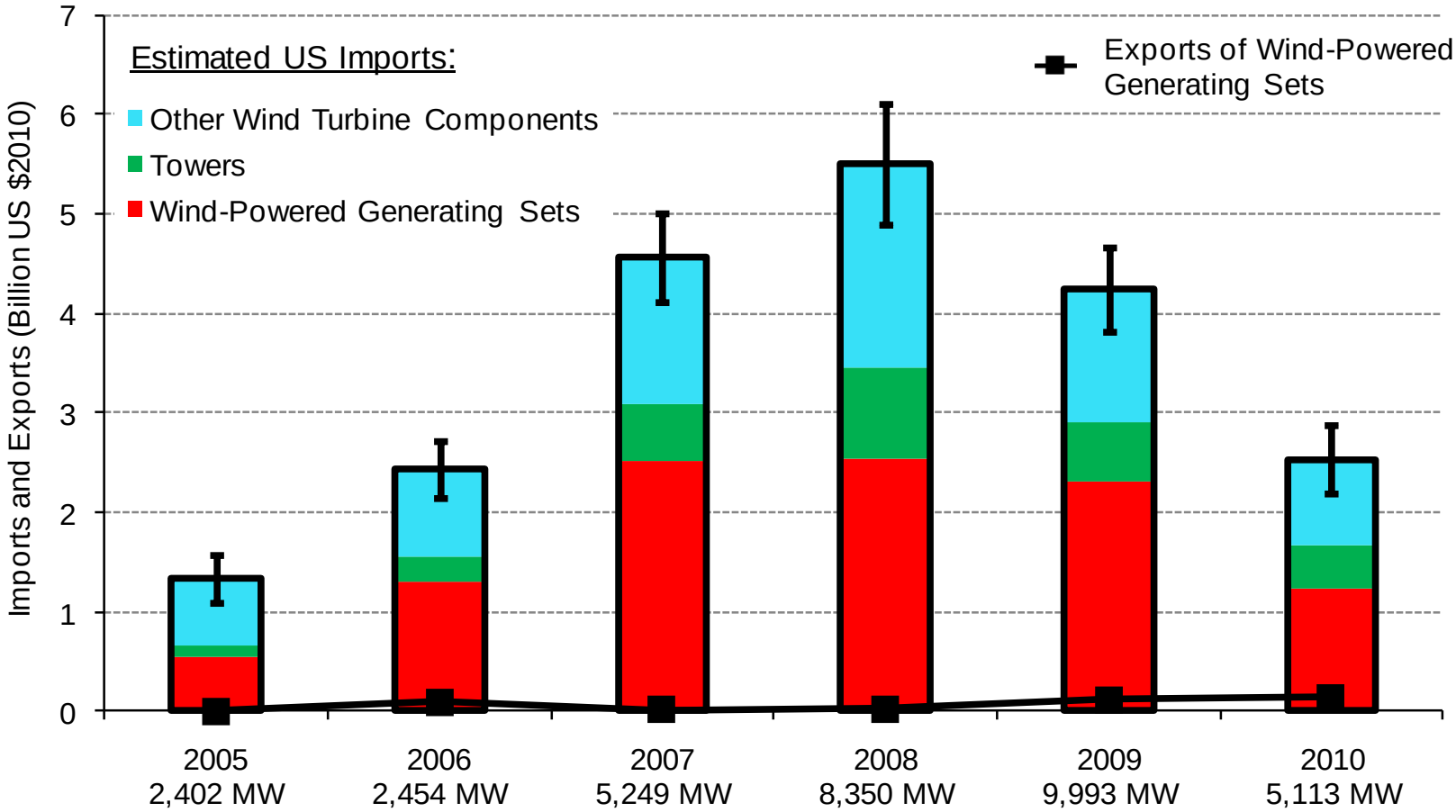
This map was created by NREL for the U.S. Department of Energy.
April 25, 2011
Billy J. Roberts

- Similar number of new wind manufacturing facilities opened in 2010 as in 2009
- 9 of 11 turbine OEMs with largest share of US market in 2010 have one or more manufacturing facilities in the US; compares to one such OEM in 2004
- Chinese and South Korean OEMs continue to make progress in entering the US market

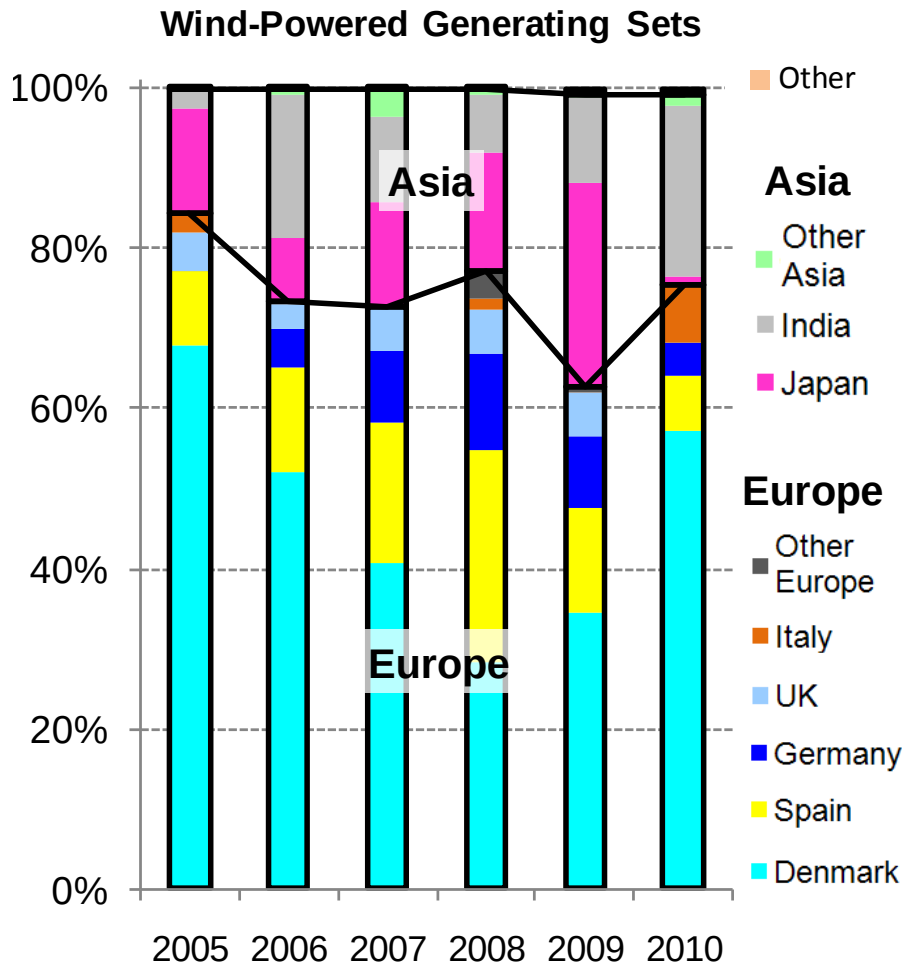
Growth in Manufacturing Capability / Drop in Installations Led to Over-Capacity of U.S. Nacelle Assembly Capability in 2010

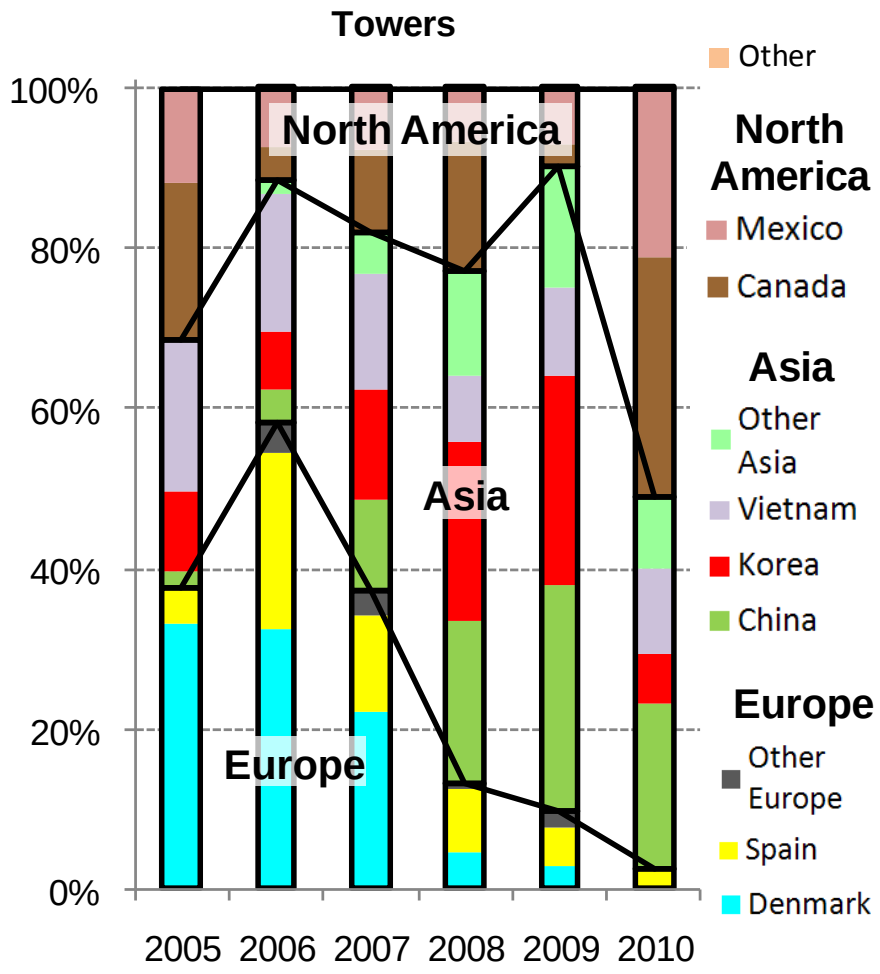


Estimated U.S. Imports of Wind-Related Equipment Dropped in 2010; Exports Increased Modestly

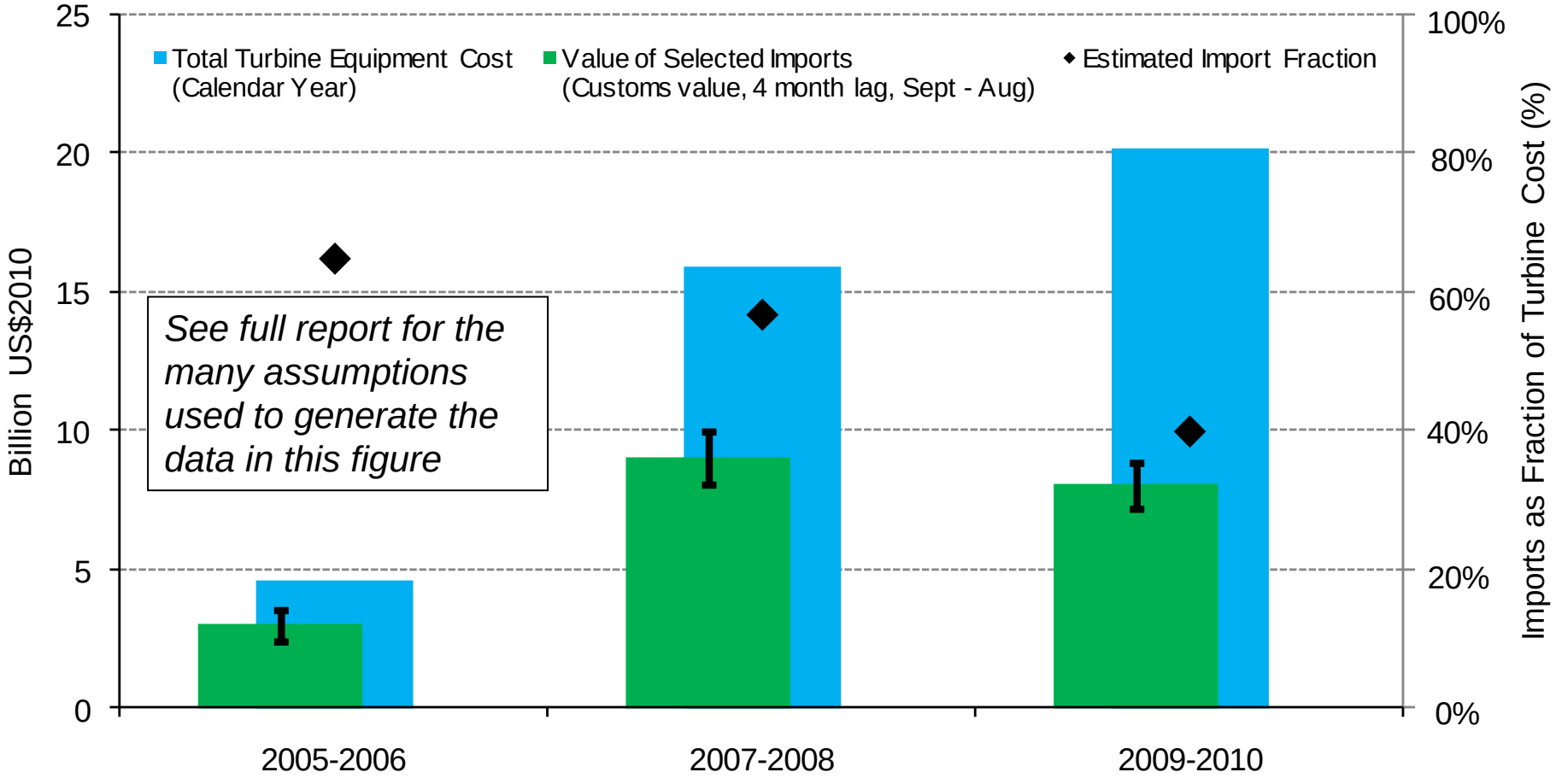


Source Markets for Imports Have Varied Over Time, and By Type of Wind Equipment



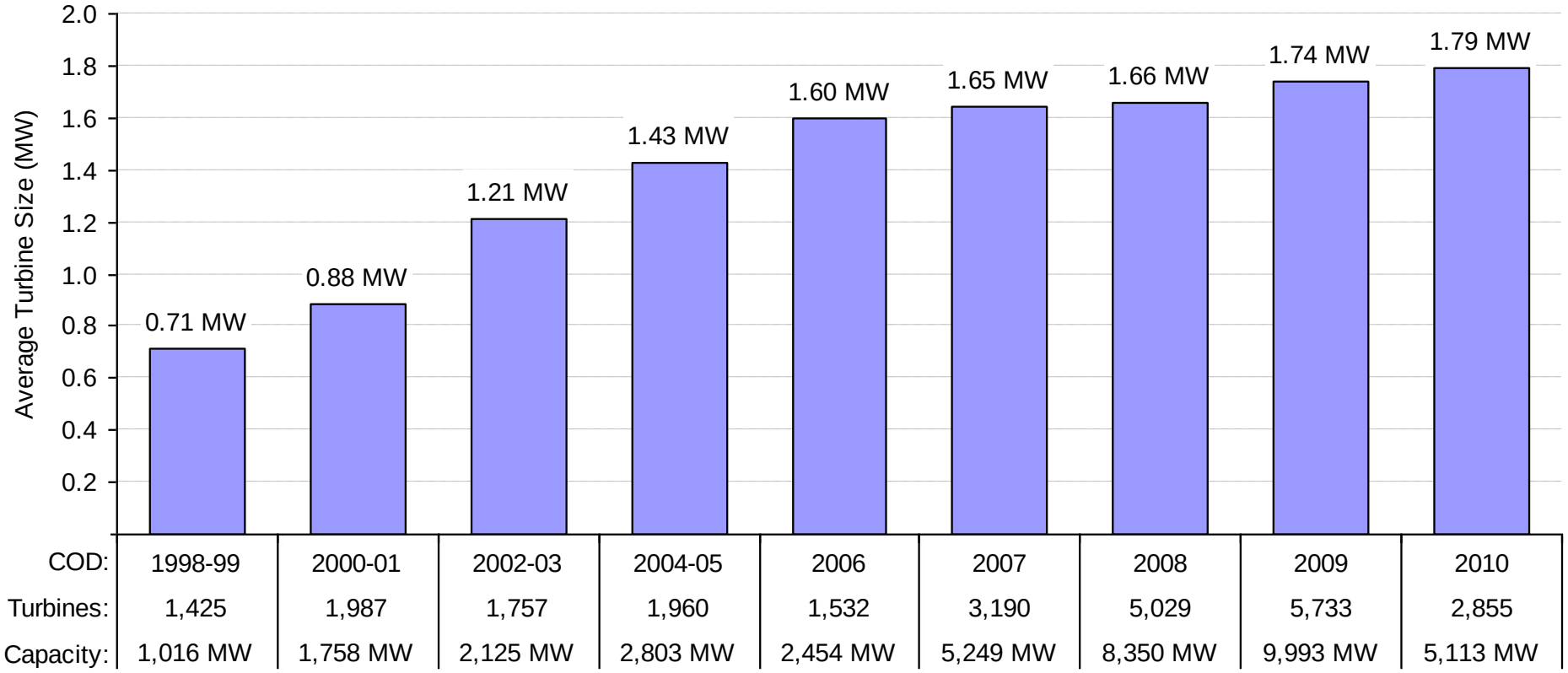


A Growing % of Equipment Used in U.S. Projects Has Been Sourced Domestically



- Import fraction has dropped from 65% in 2005-06 to 40% in 2009-10

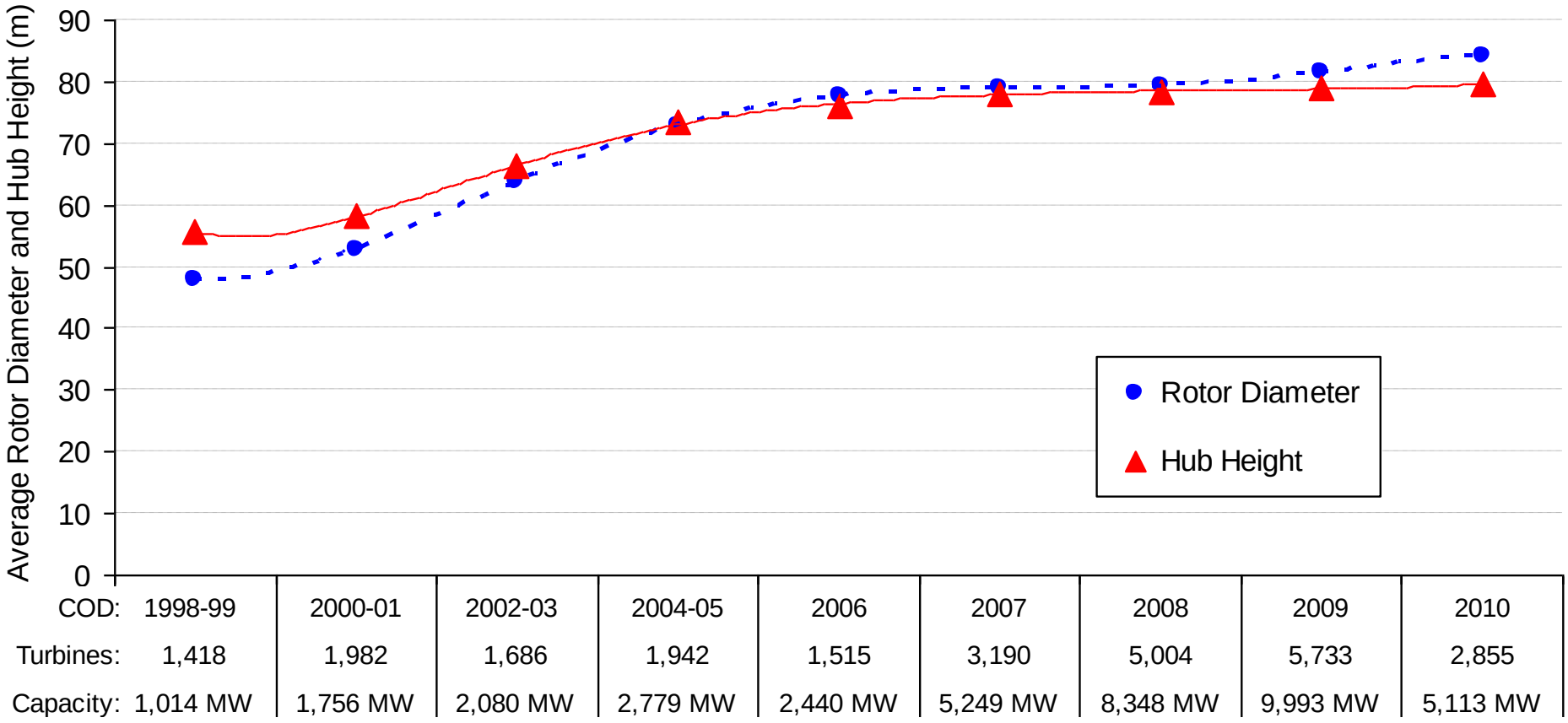
Average Turbine Size Increased in 2010



COD:	1998-99	2000-01	2002-03	2004-05	2006	2007	2008	2009	2010
Turbines:	1,425	1,987	1,757	1,960	1,532	3,190	5,029	5,733	2,855
Capacity:	1,016 MW	1,758 MW	2,125 MW	2,803 MW	2,454 MW	5,249 MW	8,350 MW	9,993 MW	5,113 MW

27% of turbines installed in 2010 were > 2.0 MW, up from 25% in 2009, 19% in 2008, 16% in 2006 & 2007, and just 0.1% in 2004-05

Average Hub Heights and Rotor Diameters Have Increased Over Time



COD:	1998-99	2000-01	2002-03	2004-05	2006	2007	2008	2009	2010
Turbines:	1,418	1,982	1,686	1,942	1,515	3,190	5,004	5,733	2,855
Capacity:	1,014 MW	1,756 MW	2,080 MW	2,779 MW	2,440 MW	5,249 MW	8,348 MW	9,993 MW	5,113 MW

On average, since 1998-99, hub heights are 24 meters (43%) higher and rotor diameters are 36 meters (76%) larger

Developer Consolidation Slowed in 2010

Acquisition and investment activity among U.S. wind developers:

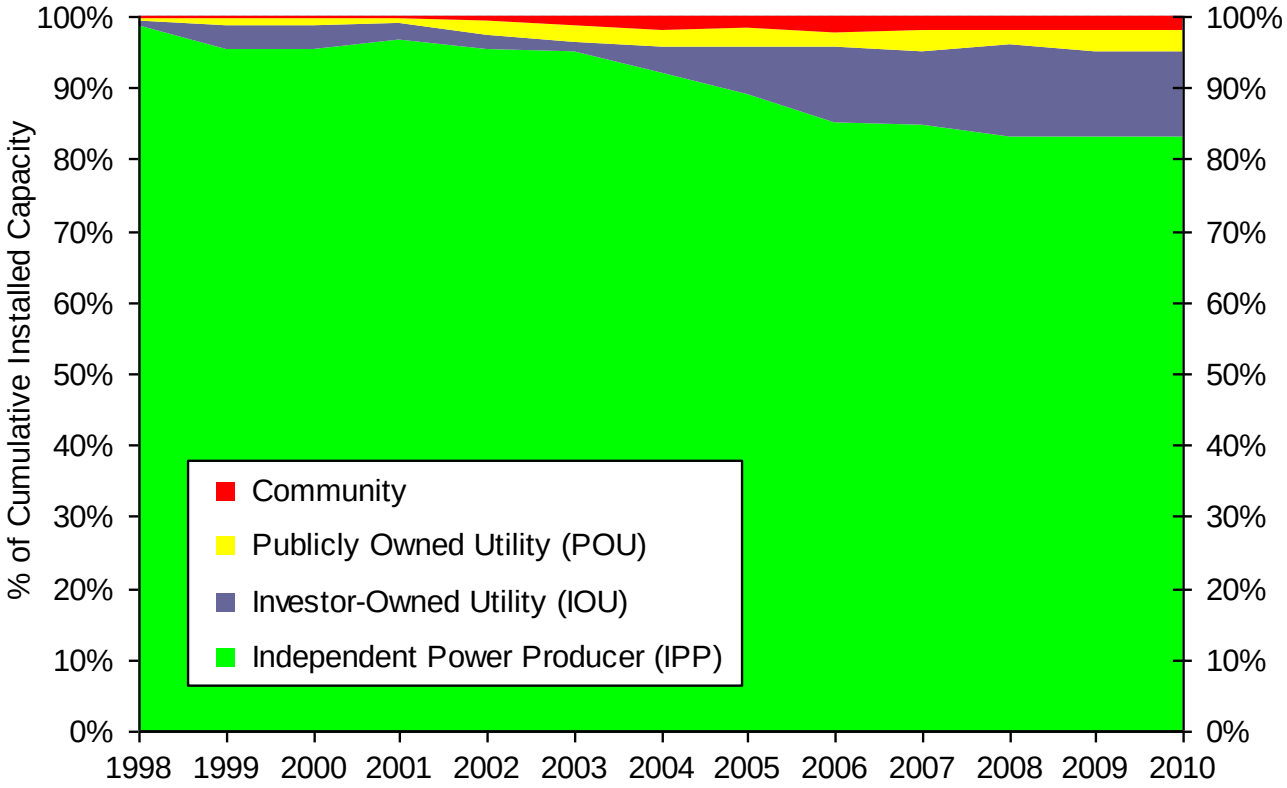
- **2010:** at least 3 deals = 10 GW of wind development pipeline
- **2009:** 6 deals = 18 GW
- **2008:** 5 deals = 19 GW
- **2007:** 11 deals = 37 GW
- **2006:** 12 deals = 34 GW
- **2005:** 8 deals = 11 GW
- **2002-04:** 4 deals = 4 GW

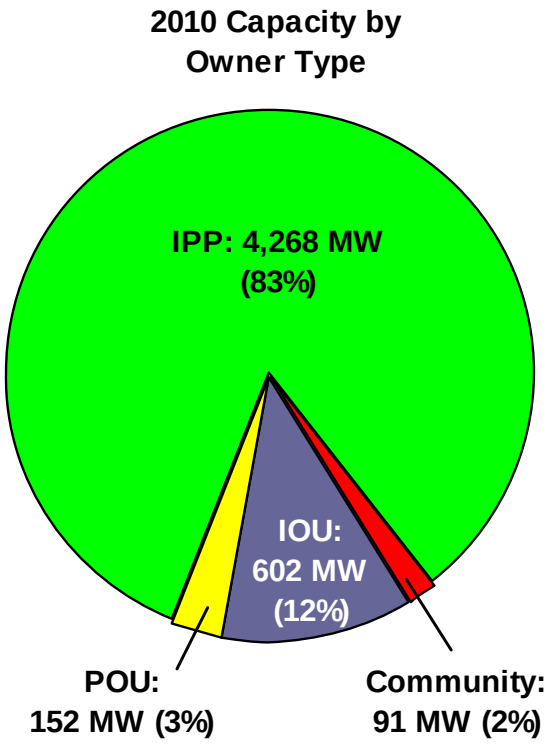
Slowed activity may be the result of: the fact that many of the prime targets were acquired in previous years; the global financial crisis; increasing prevalence of sales of portions of project pipelines rather than all-out acquisition of developers

Project Finance Environment Steadily Improved Throughout 2010

- Tax equity recovered in volume, but not necessarily pricing
  - 16 active investors, including several unconventional (e.g., Google)
  - Continued structural innovation: e.g., several sale/leasebacks
  - Investment volume twice as much as 2009
  - But yields higher than pre-crisis levels at 7.5-8.5% for least-risky projects
- Brisk activity in the debt markets
  - 30 banks active in construction financing, grant bridge loans, term debt
  - Tenors lengthened: fully amortizing 15-year loans available by end of year
  - Interest rate spreads fell, such that all-in rates of ~6% were achievable
  - Institutional lenders also returned
  - Four DOE loan guarantees for wind projects

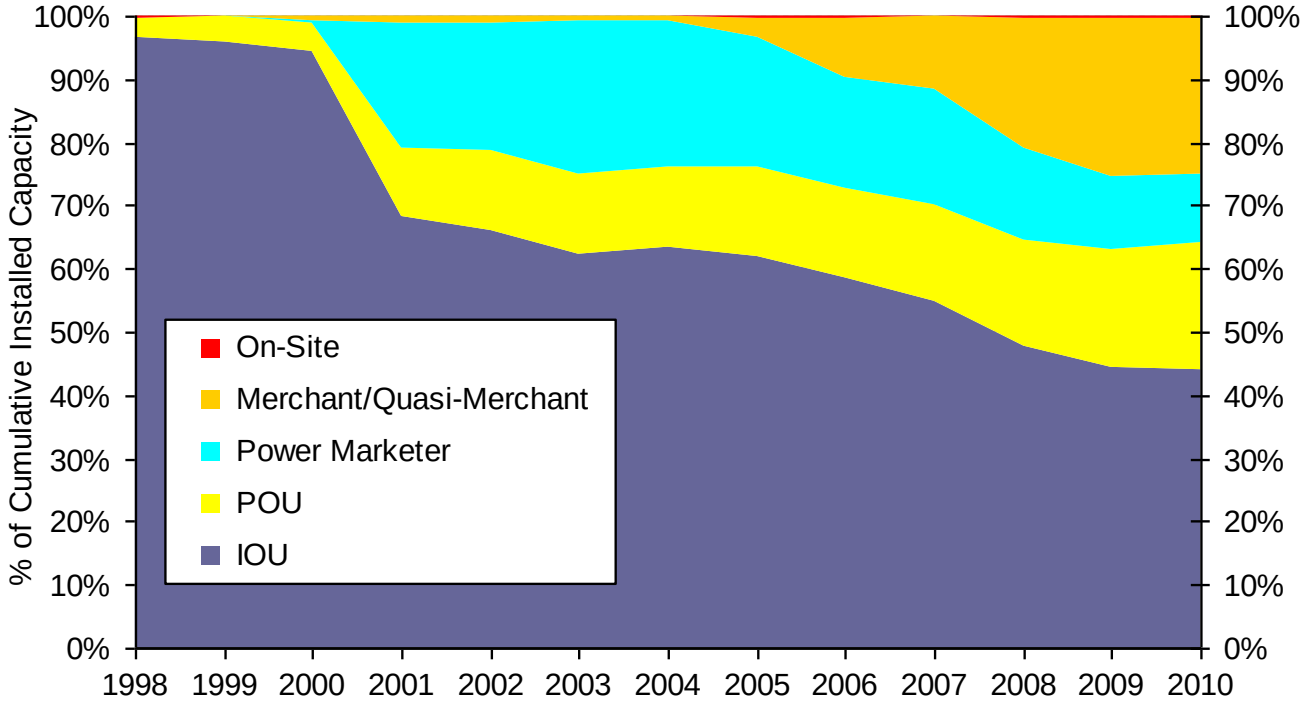
IPP Project Ownership Remained Dominant

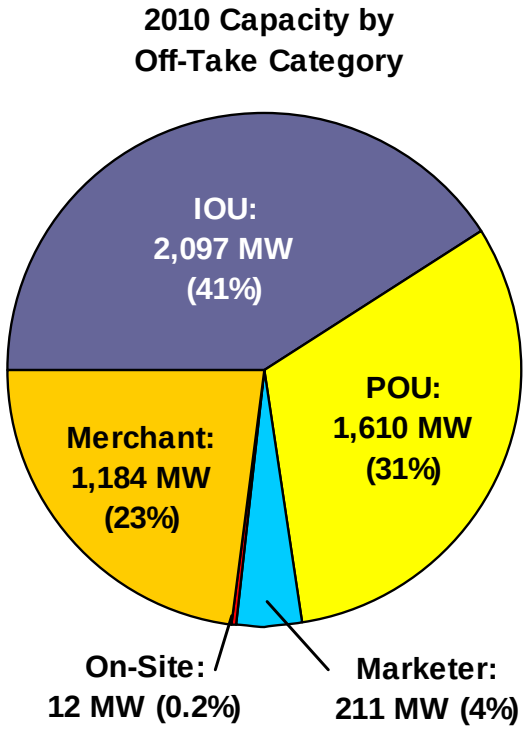




- Utility and community ownership held steady in 2010

Electric Utilities Still the Dominant Off-Takers of Wind Power in 2010





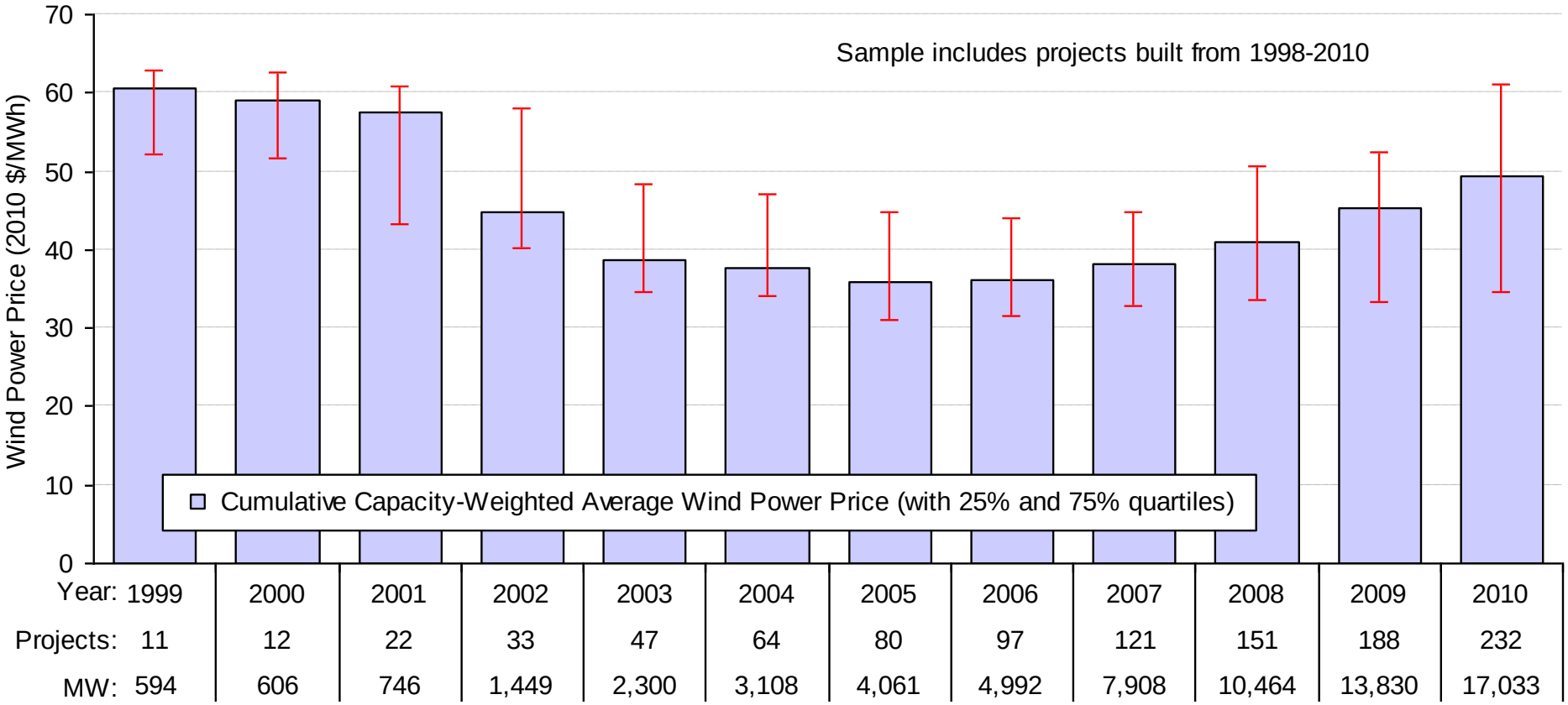
- Publicly owned utility share grew; investor owned utility share shrank
- "Merchant" activity continued but at reduced pace compared to 2009

Price, Cost, and Performance Trends

Wind Power Prices from Projects Built in 2010 Were Higher, But Relief is On the Way

- Berkeley Lab maintains a database of historical wind power sales prices; next few slides present data from that database
- Sample includes 232 projects built from 1998-2010, totaling 17,033 MW (44% of all wind capacity added in that period)
- Prices reflect the historical bundled price of electricity and RECs as sold by the project owner under a power purchase agreement
  - Dataset excludes merchant plants and projects that sell renewable energy certificates (RECs) separately
  - Prices reflect receipt of state and federal incentives (e.g., the PTC or Treasury grant), as well as various loca policy and market influences; as a result, prices do not reflect wind energy generation costs

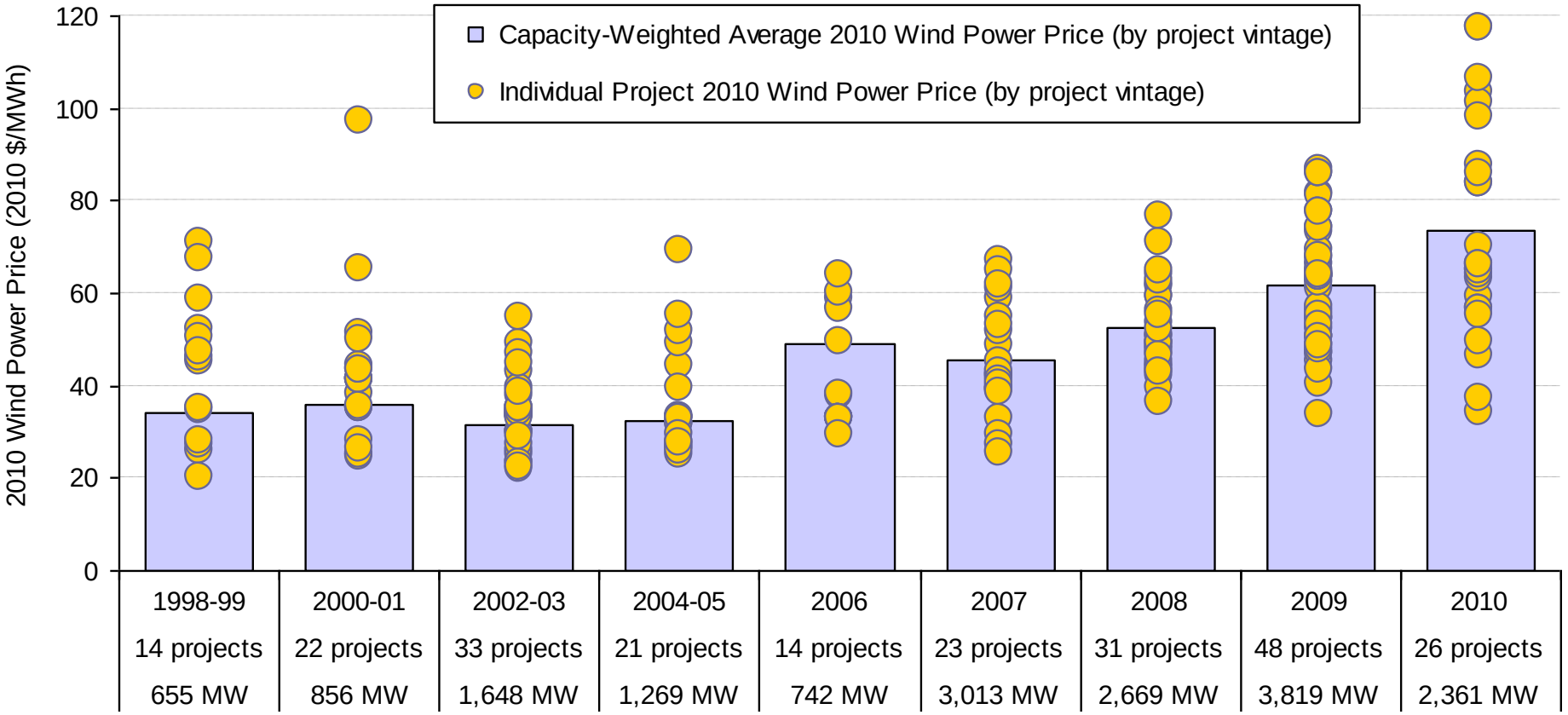
Cumulative Average Sales Price for Sample of Projects Built After 1997 Low But Rising



Year:	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Projects:	11	12	22	33	47	64	80	97	121	151	188	232
MW:	594	606	746	1,449	2,300	3,108	4,061	4,992	7,908	10,464	13,830	17,033

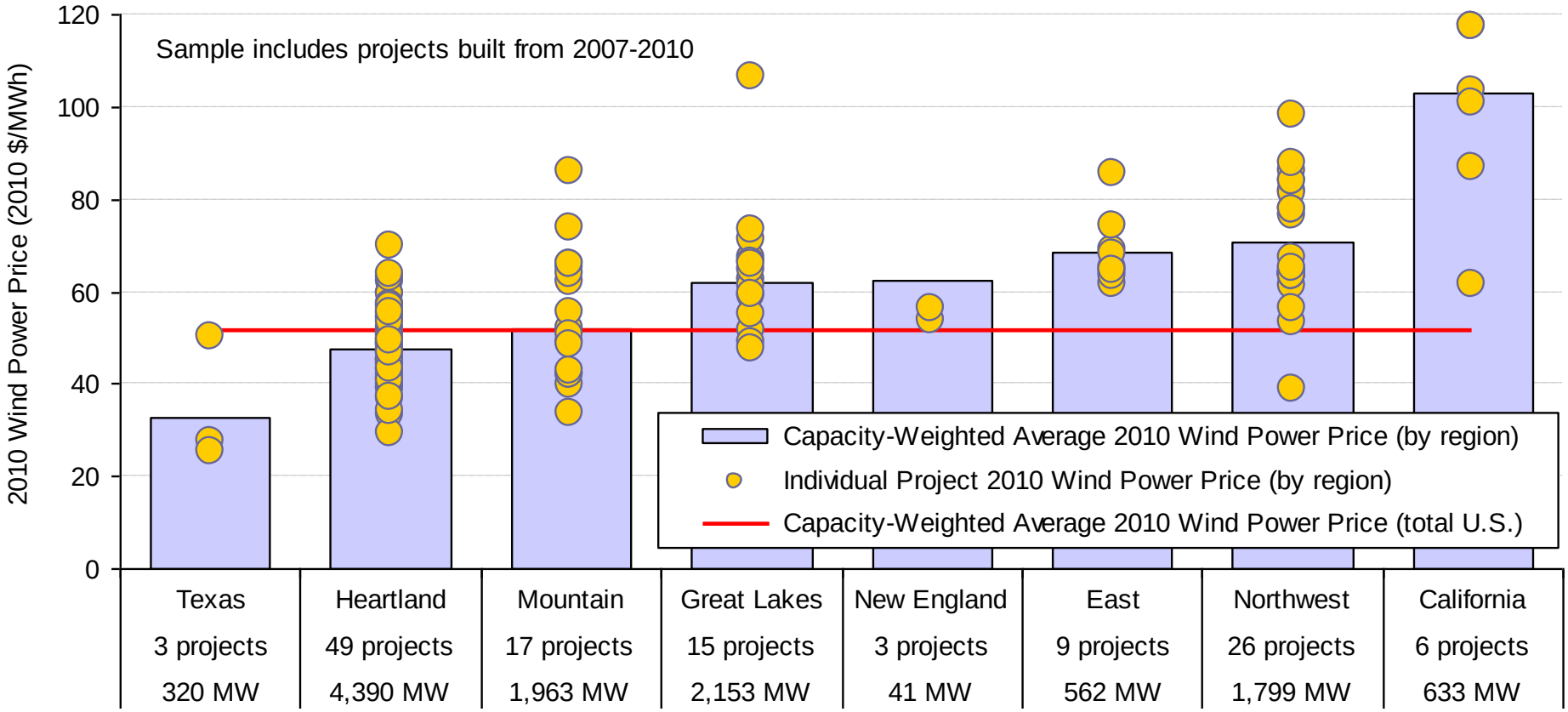
Increase in prices since 2005 due to rising prices from newly built projects, but cumulative nature of graphic mutes degree of apparent price increase

Binning by Commercial Operation Date Shows that Prices Have Increased Since 2005



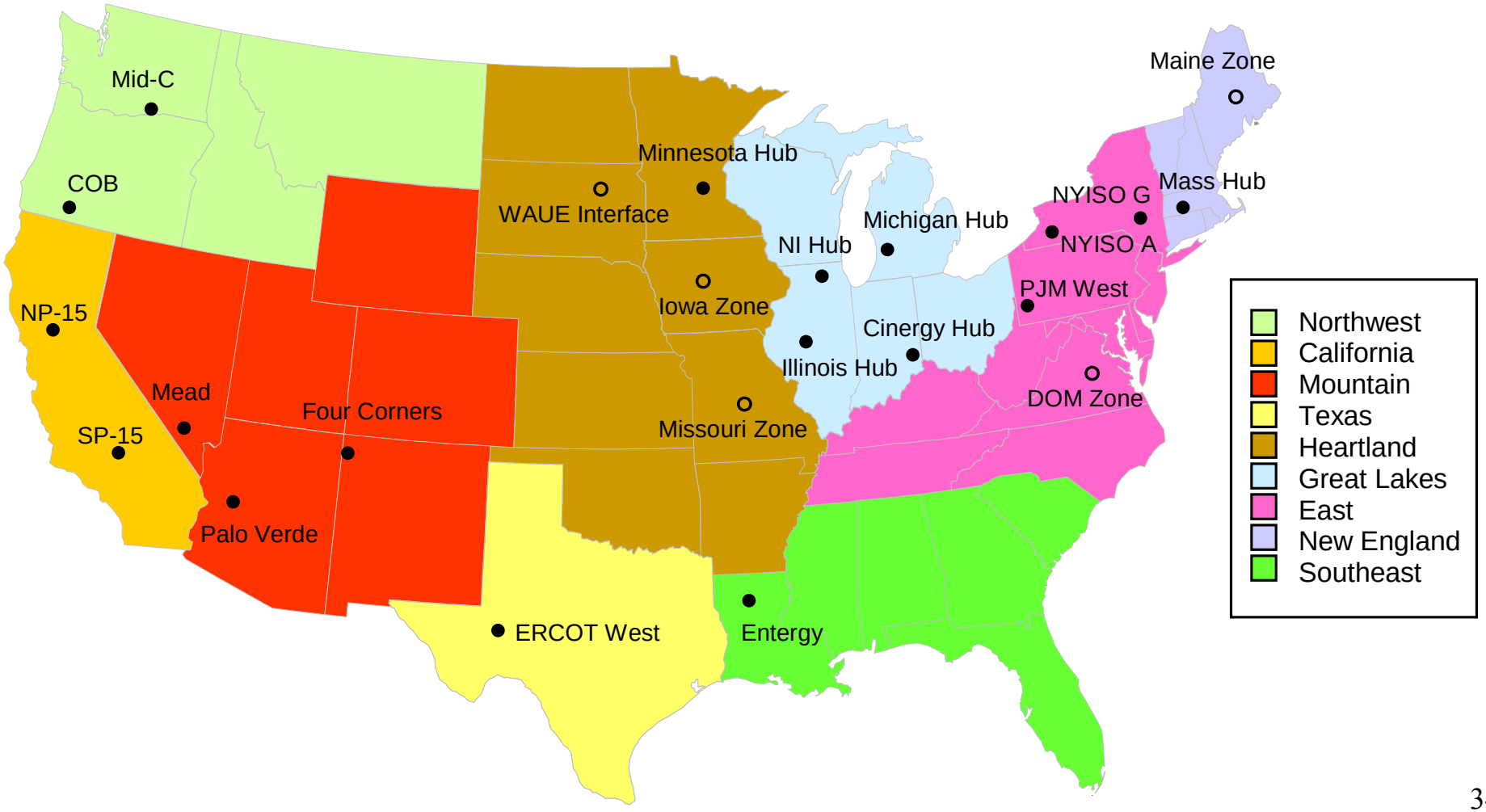
Graphic shows prices in 2010 from projects built from 1998-2010

Regional Differences Explain Some of the Underlying Variability in Wind Sales Prices

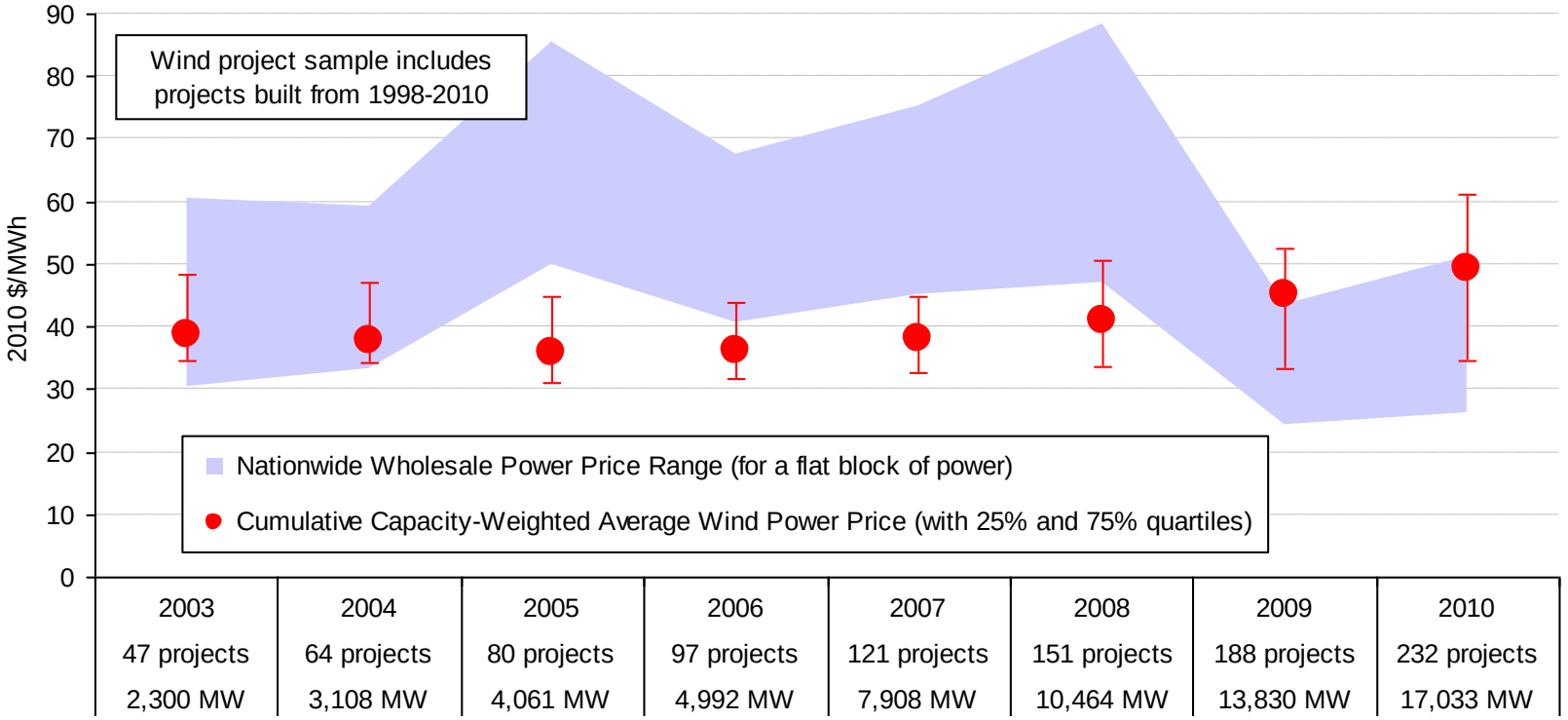


Though sample size is problematic in both regions, Texas and California represent opposite extremes of the regional breakdown

Regions and Wholesale Price Hubs Used in Analysis

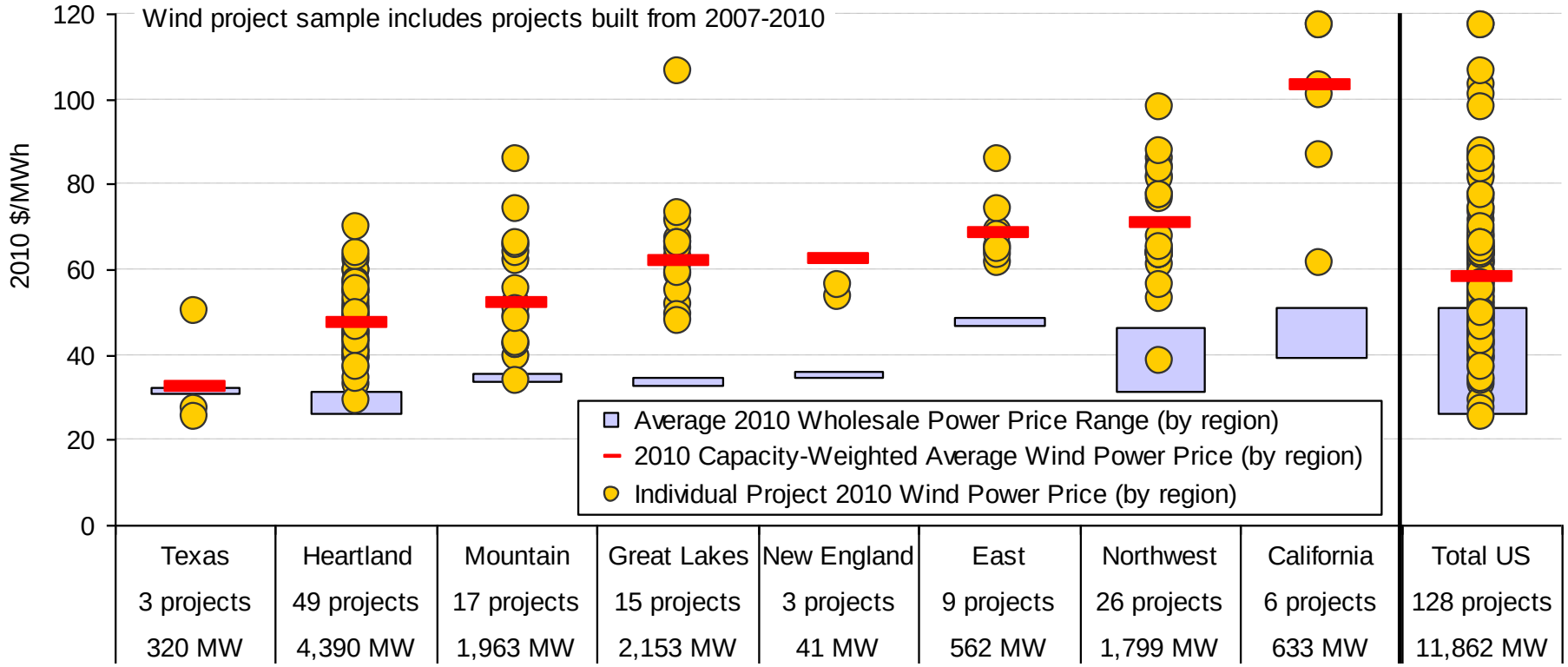


Low Wholesale Electricity Prices Continued to Challenge the Relative Economics of Wind Plants Installed in Recent Years



- Wholesale price range reflects flat block of power across 23 pricing nodes (see previous map)
- Recent wholesale prices reflect low natural gas prices, driven by weak economy and shale gas
- Price comparison shown here is far from perfect – ***see full report for caveats***

The Gap Between Wholesale Prices and Wind Prices Crossed all Regions in 2010

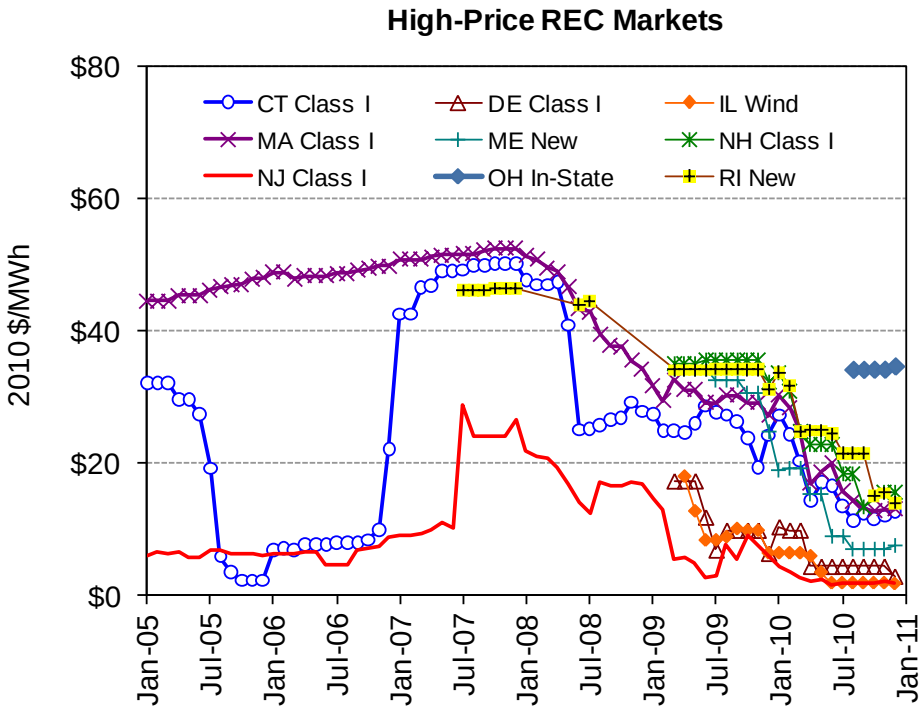


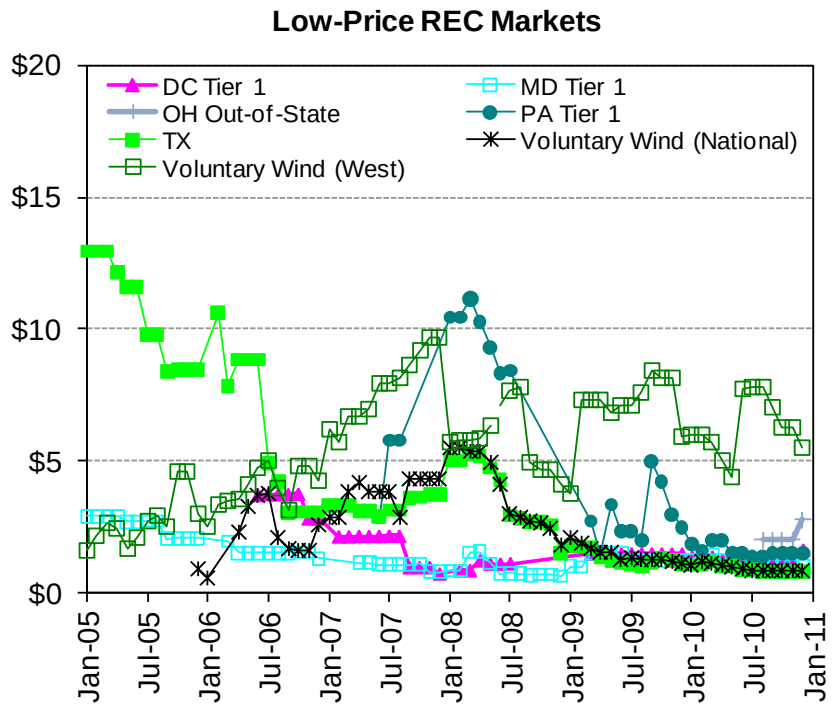
Notes: Within a region there are a range of wholesale power prices because multiple wholesale price hubs exist in each area (see earlier map); price comparison shown here is far from perfect – ***see full report for caveats***

Pricing Relief Is Anticipated in Near Future

- Wind power projects built in 2010 had relatively high prices, on average, due in part to:
  - Turbines purchased and power purchase agreements negotiated in ~2008, at peak of wind turbine pricing
  - Prevalence of California projects in 2010 sample: excluding CA projects from 2010, capacity-weighted average prices for 2010 projects drops from $73/MWh to $64/MWh
  - Recent general trend towards building-out lower wind speed sites as a result of policy and market drivers
- Pricing thaw apparent: a number of recent power purchase agreements in the low-to-mid $40/MWh range (and in some cases even lower) have been witnessed

Renewable Energy Certificate (REC) Prices Fell in Most Compliance Markets

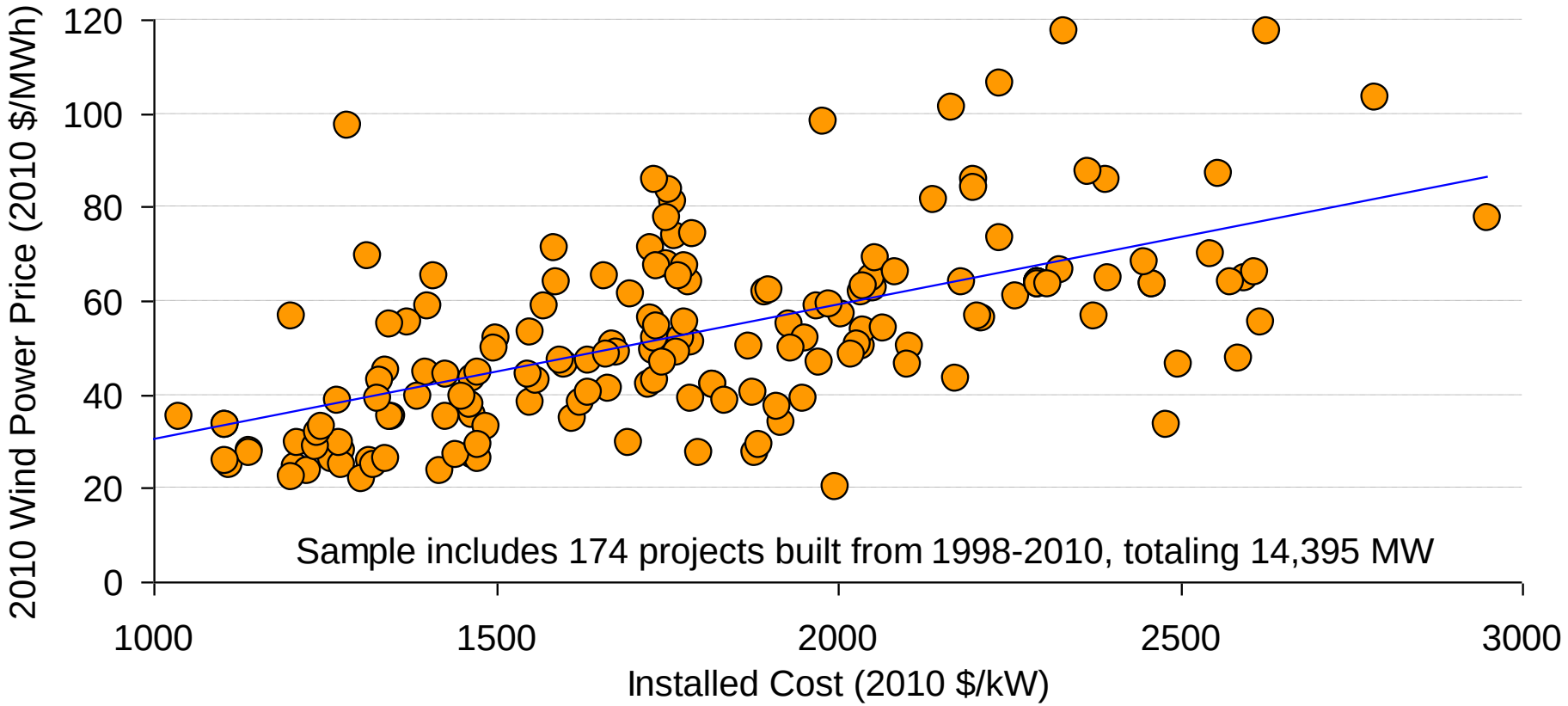




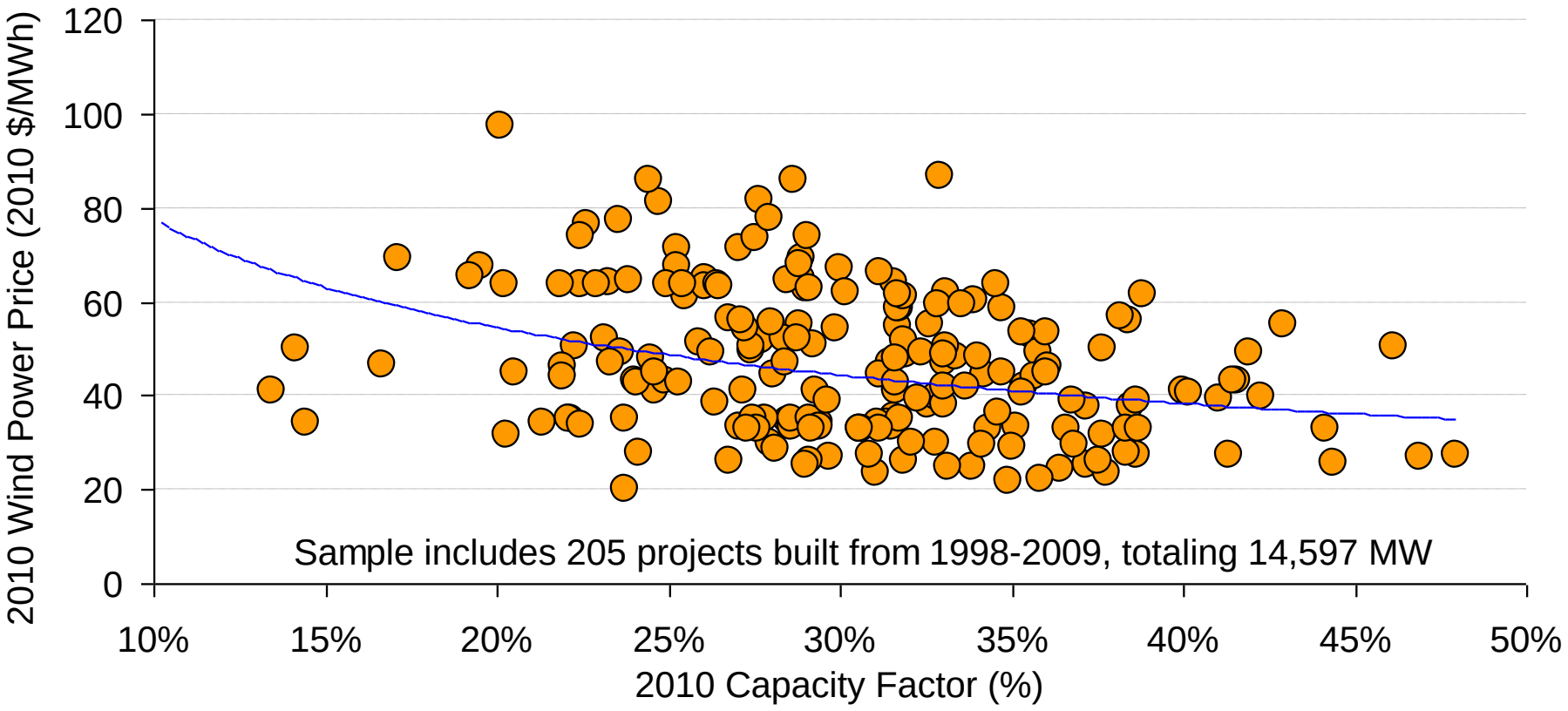
REC prices vary by:

- Market type: compliance vs. voluntary
- Geographic region
- Specific design of state RPS policies

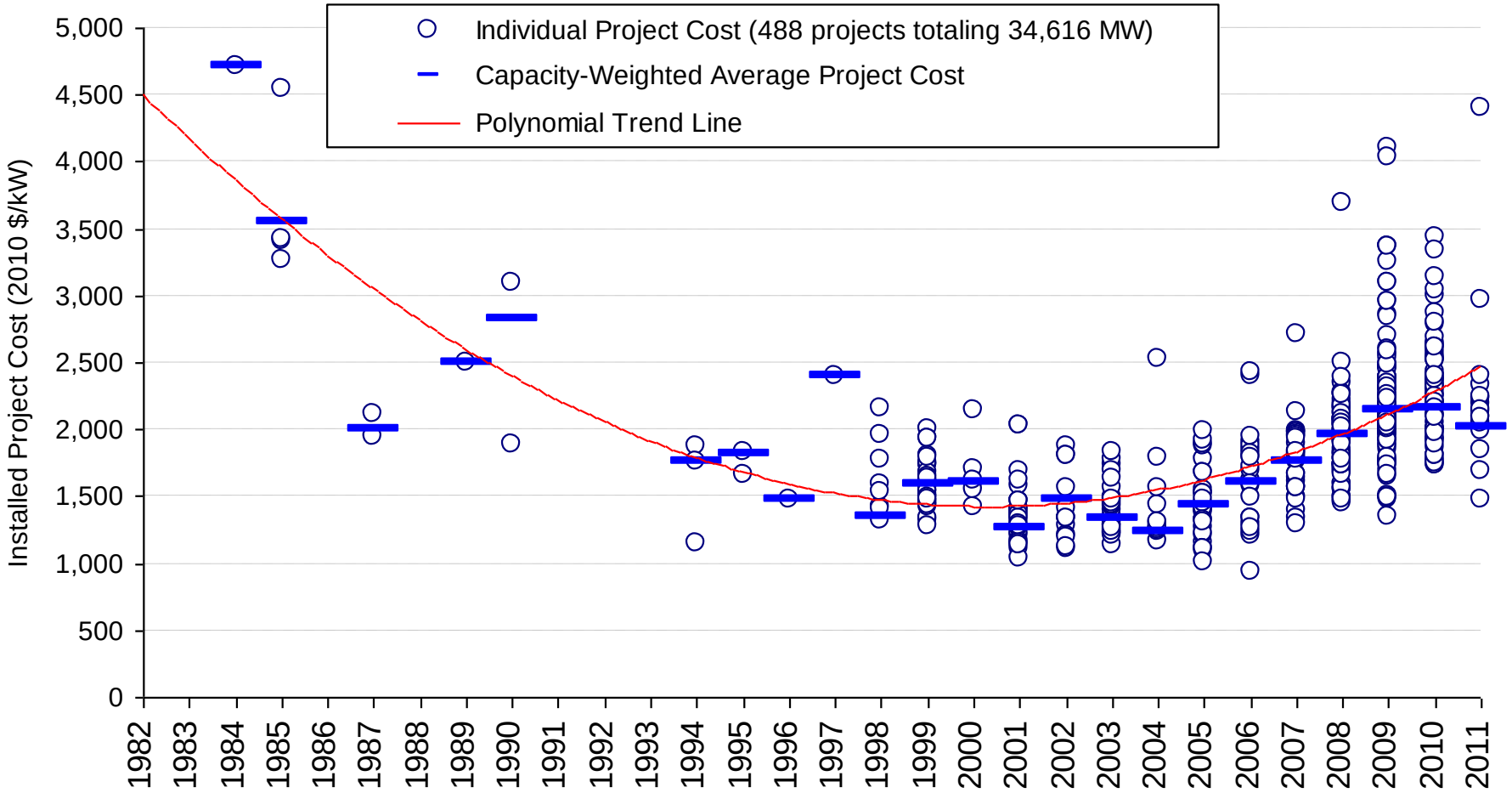
Wind Power Sales Prices Are Affected by Installed Project Costs...



...and by Wind Power Project Performance

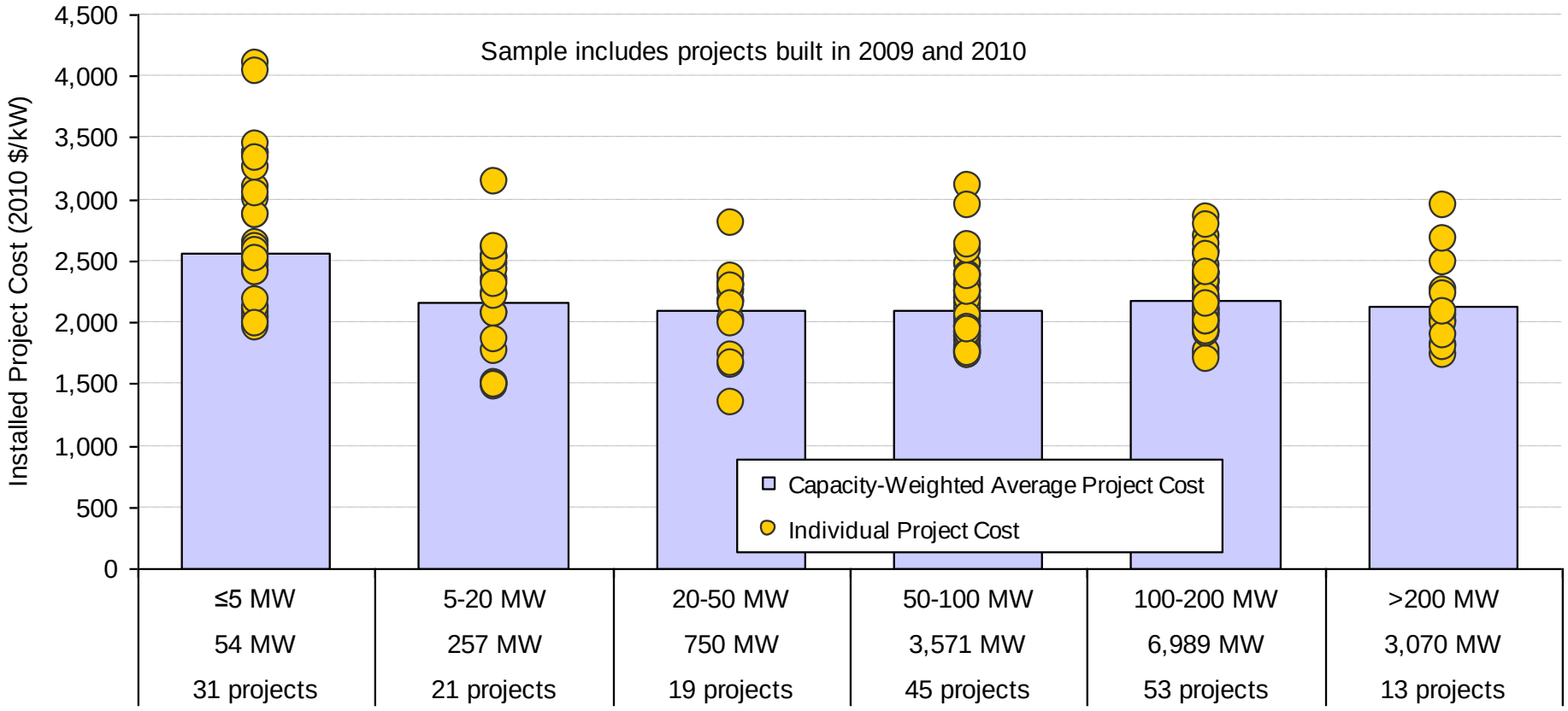


The Average Installed Cost Held Steady in 2010, But Is Expected to Decline in 2011/12

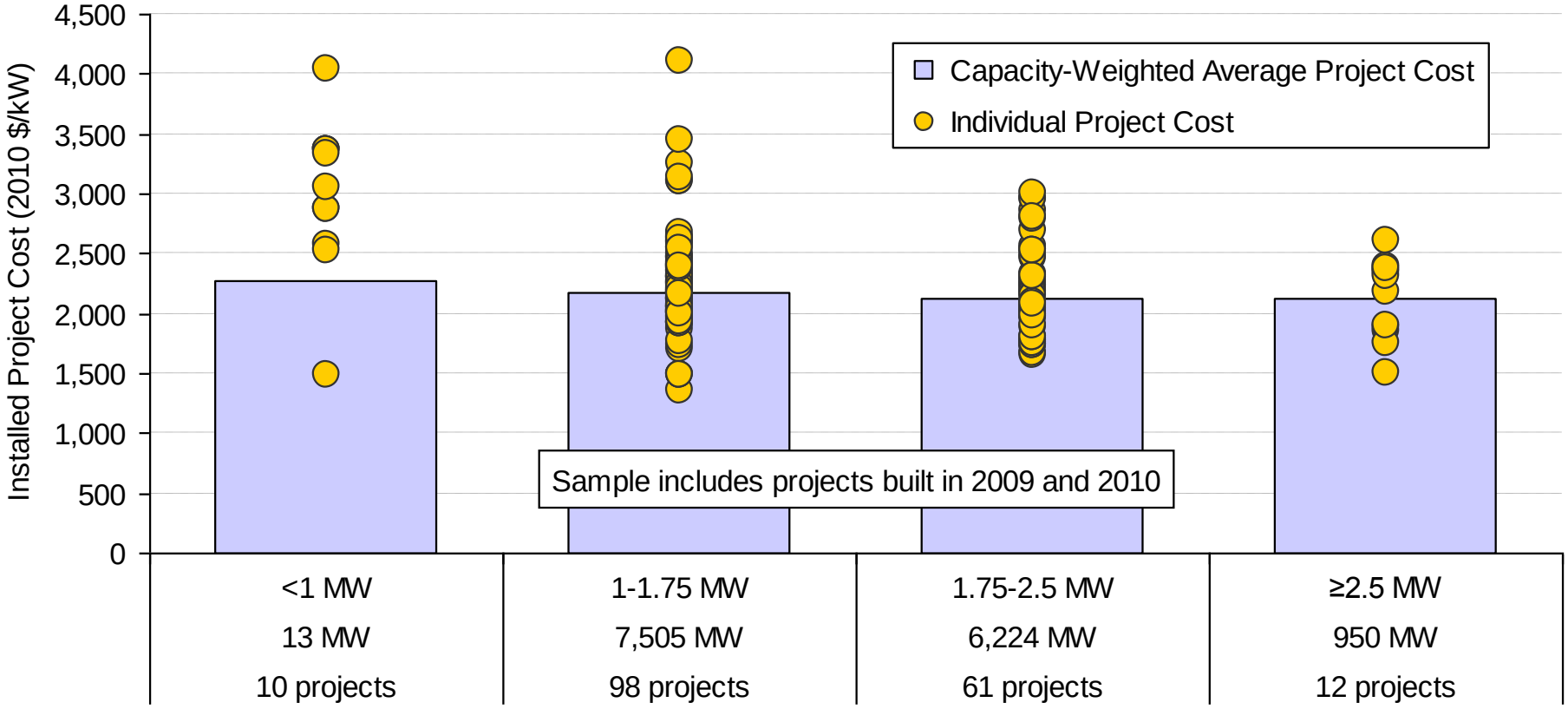


Note: 2011 sample of 17 projects totaling ~1 GW is preliminary

Economies of Scale Evident At Low End of Project Size Range

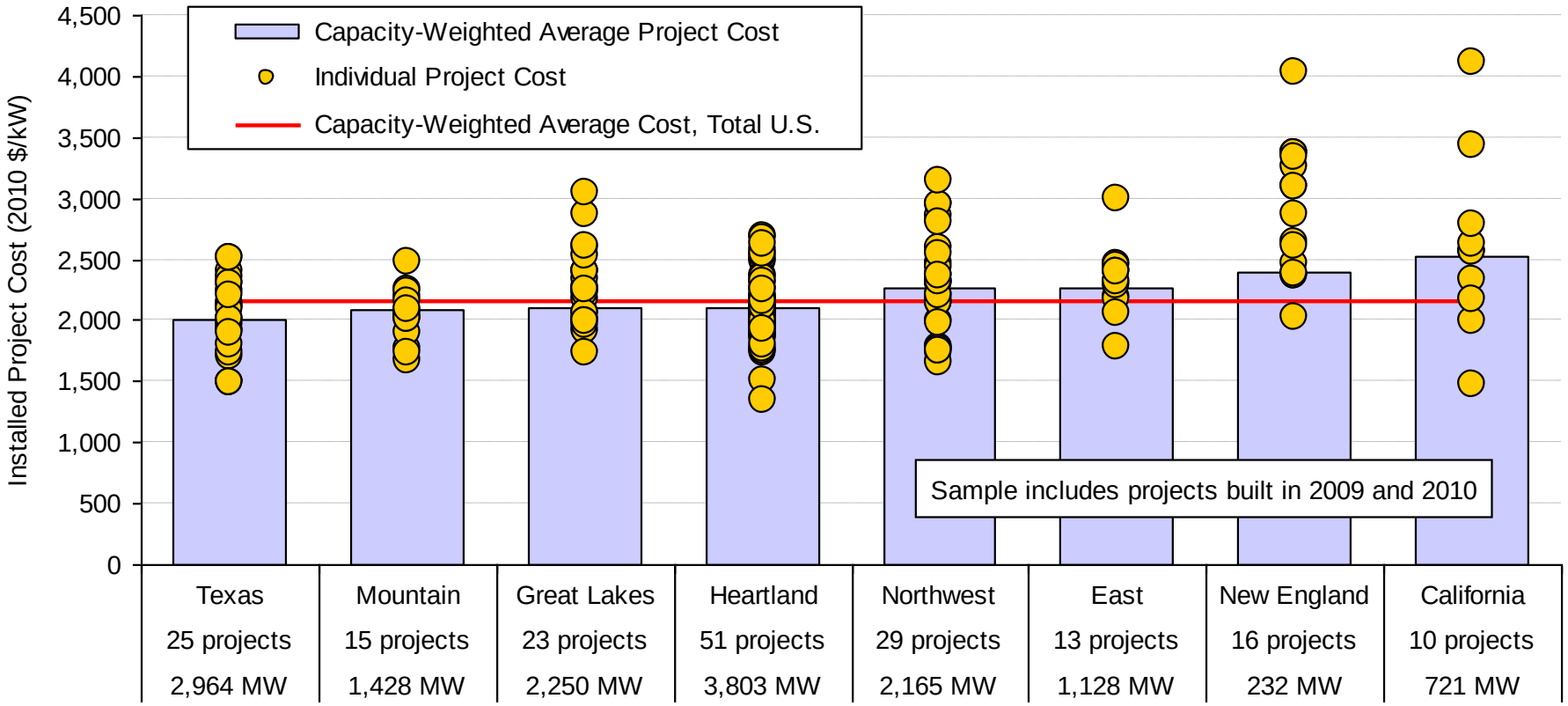


Economies of Scale Also Evident (Though Less So) By Turbine Size



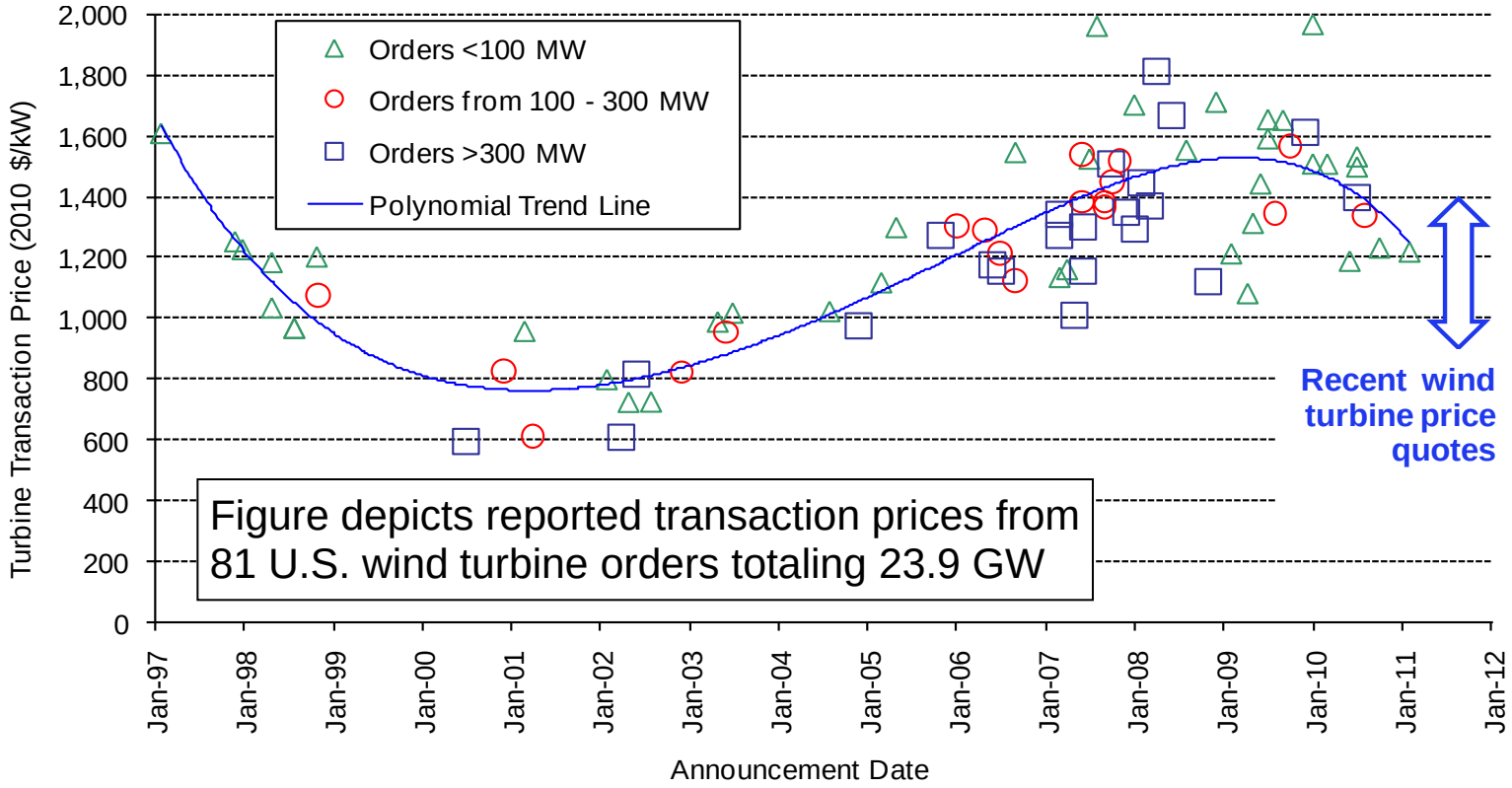
Theory: A project may be built less-expensively using fewer larger turbines instead of a larger number of smaller turbines

Some Regional Differences in Wind Power Project Costs Are Apparent



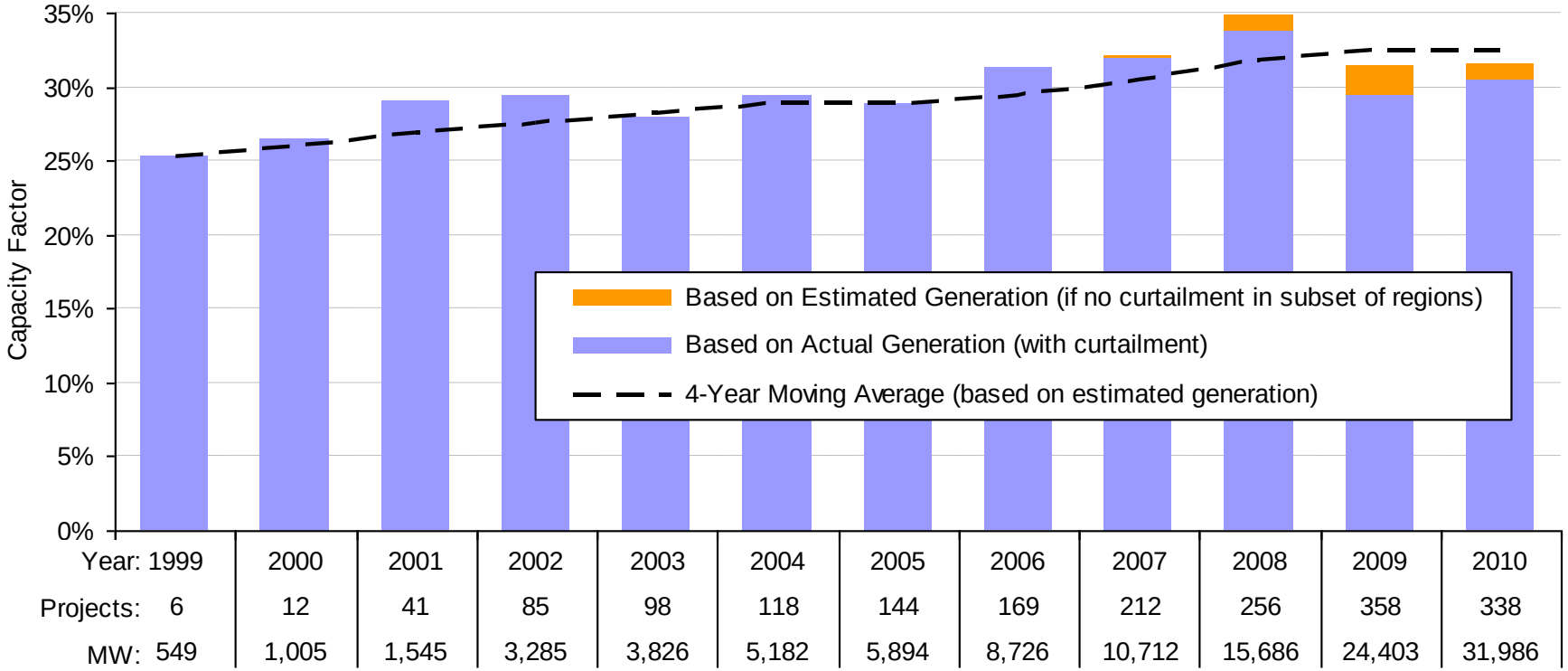
Different permitting/compliance costs may play a role at both ends of the spectrum: it's easier to build in TX and more difficult in CA

Much Lower Turbine Pricing and Lag Between Turbine Purchase and Project Installation Will Yield Lower Project Costs in Years Ahead



Recent turbine price quotes rumored to be <u>as low as</u> $900/kW, with more-favorable terms for buyers and improved technology

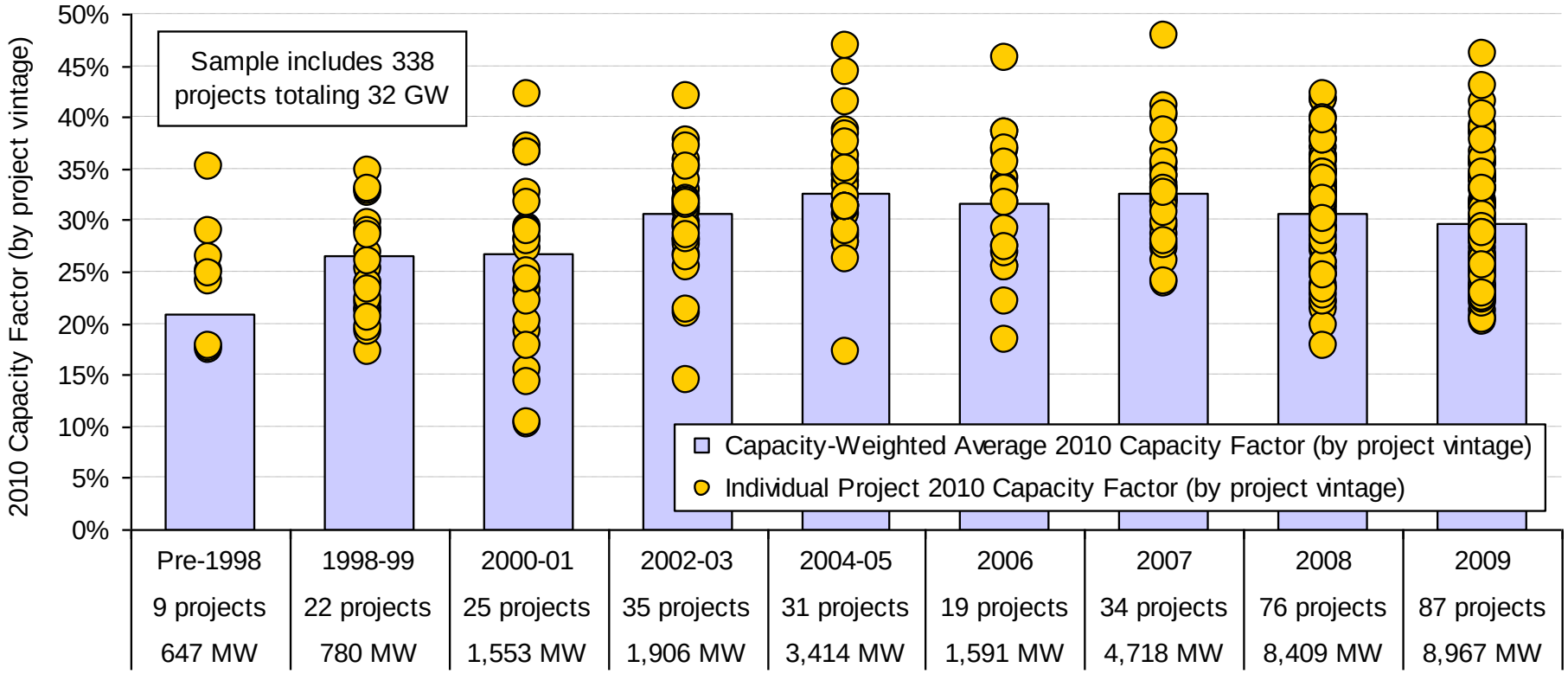
Average Capacity Factors Have Improved Over Time, But Leveled Off in Recent Years



Year:	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Projects:	6	12	41	85	98	118	144	169	212	256	358	338
MW:	549	1,005	1,545	3,285	3,826	5,182	5,894	8,726	10,712	15,686	24,403	31,986

- General improvement reflects increase in hub height and rotor diameter (see slide 24)
- Inter-annual wind resource variation also plays a role: 2009 was a bad wind year
- Developers increasingly relying on lower wind speed sites, using improved technology
- Curtailment another major factor in recent years (see slide 48)

Binning by Project Vintage and Focusing on 2010 Performance Tells A Similar Story



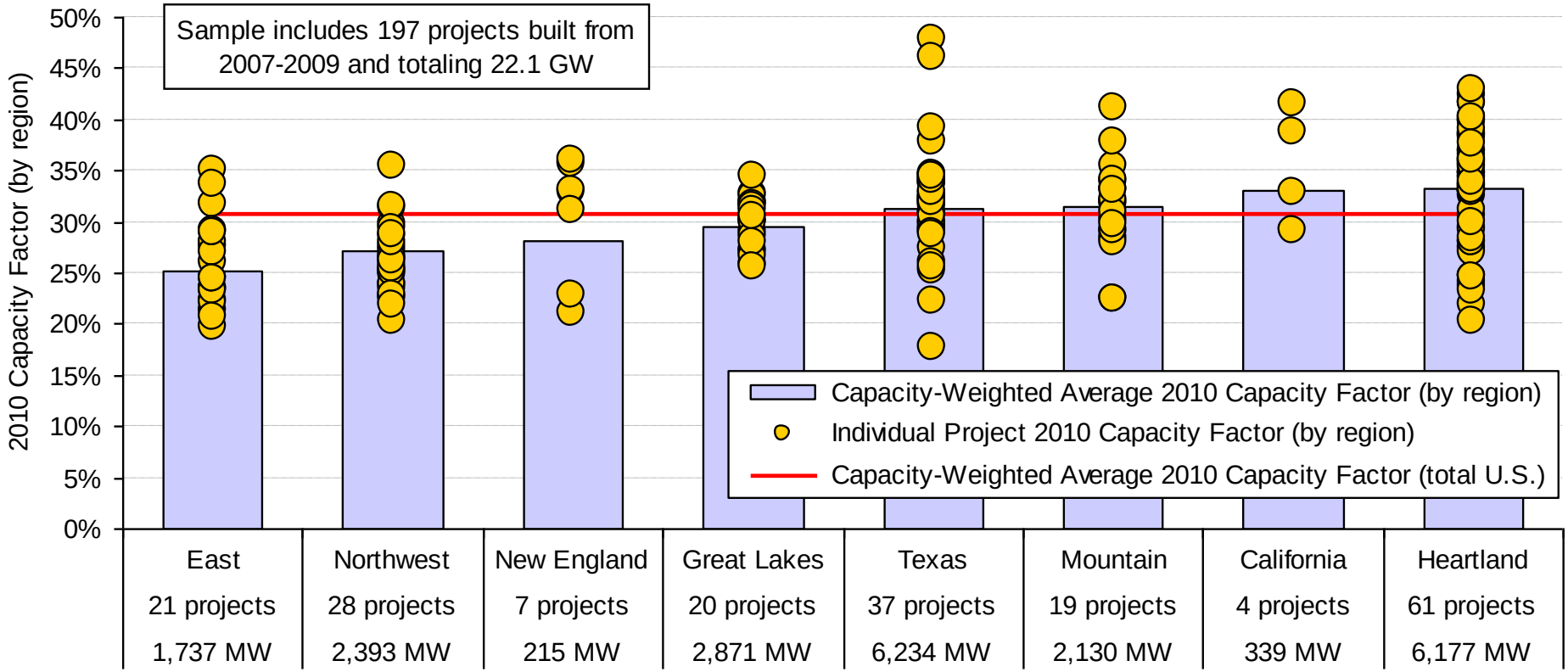
Projects installed since 2005 have bucked the trend of generally increasing capacity factors among more-recently built projects

Curtailment a Growing Issue in Some Areas

	2007	2008	2009	2010
Electricity Reliability Council of Texas (ERCOT)	109 (1.2%)	1,417 (8.4%)	3,872 (17.1%)	2,067 (7.7%)
Southwestern Public Service Company (SPS)	N/A	0 (0.0%)	0 (0.0%)	0.9 (0.0%)
Public Service Company of Colorado (PSCo)	N/A	2.5 (0.1%)	19.0 (0.6%)	81.5 (2.2%)
Northern States Power Company (NSP)	N/A	25.4 (0.8%)	42.4 (1.2%)	42.6 (1.2%)
Midwest Independent System Operator (MISO), less NSP	N/A	N/A	250 (2.2%)	781 (4.4%)
Bonneville Power Administration (BPA)	N/A	N/A	N/A	4.6* (0.1%)
Total Across These 6 Areas:	**109 (1.2%)**	**1,445 (6.4%)**	**4,183 (10.4%)**	**2,978 (5.1%)**

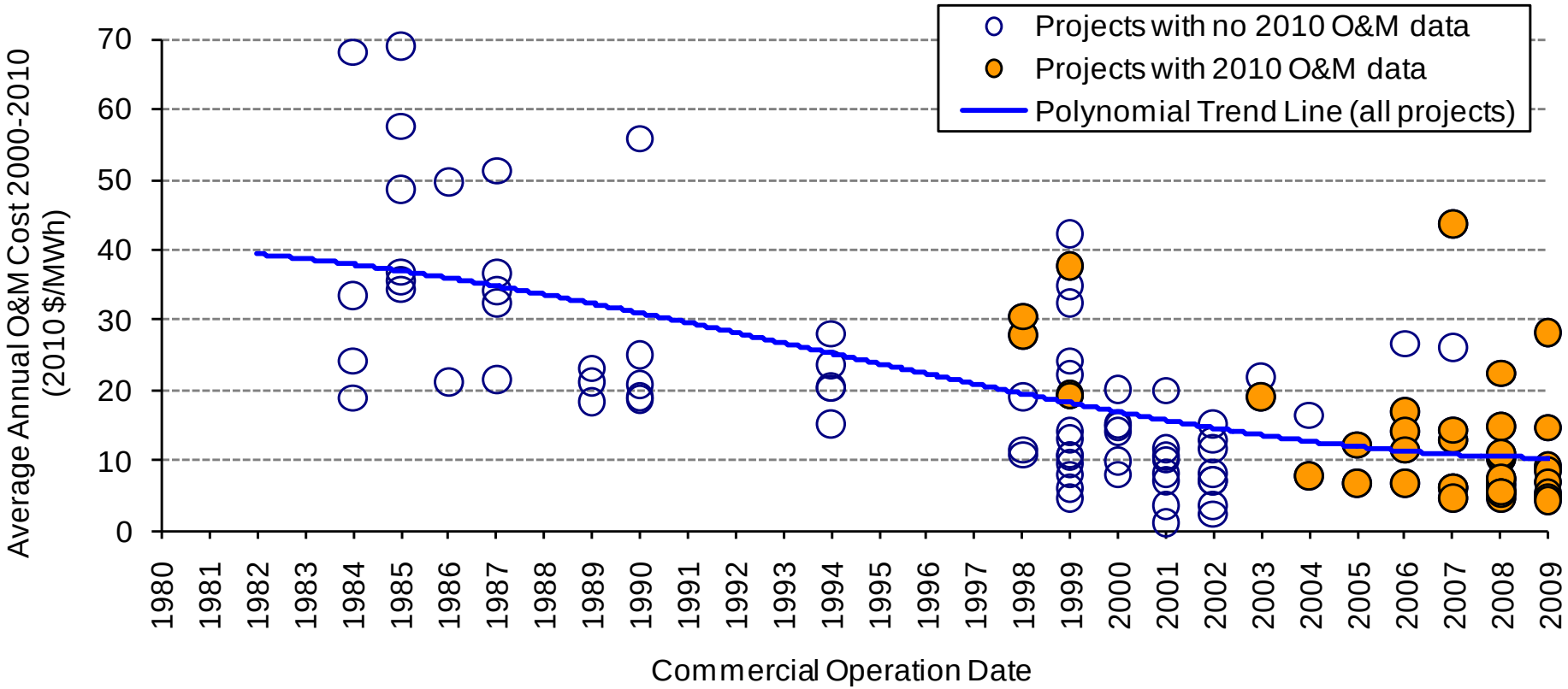
Assuming a 30% capacity factor, the total amount of wind generation curtailed in 2010 within just the six territories shown above equates to the annual output of roughly 1,130 MW of wind power capacity

Regional Performance Differences Are Apparent



Average capacity factors highest in the Heartland region, lowest in the East

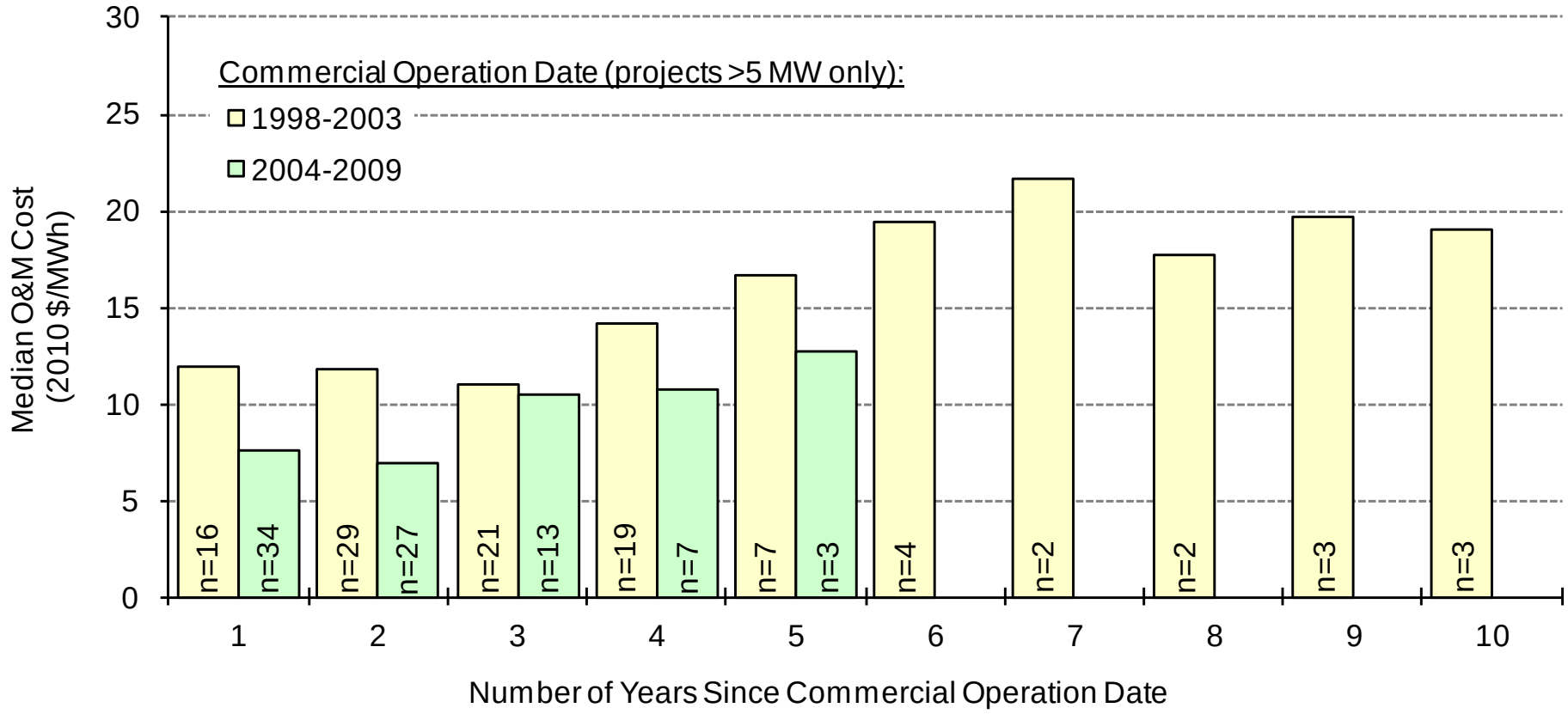
Average O&M Costs from 2000-2010 Are Affected By Year of Installation



Capacity-weighted average 2000-10 O&M costs for projects built in the 1980s equal **$33/MWh**, dropping to **$22/MWh** for projects built in 1990s, and to **$10/MWh** for projects built in 2000s

Note: Sample is limited, and consists of 126 wind power projects totaling 7,502 MW; few projects in sample have complete records of O&M costs from 2000-10

O&M Costs Appear to Increase with Project Age, and Decrease for More Recently Installed Projects



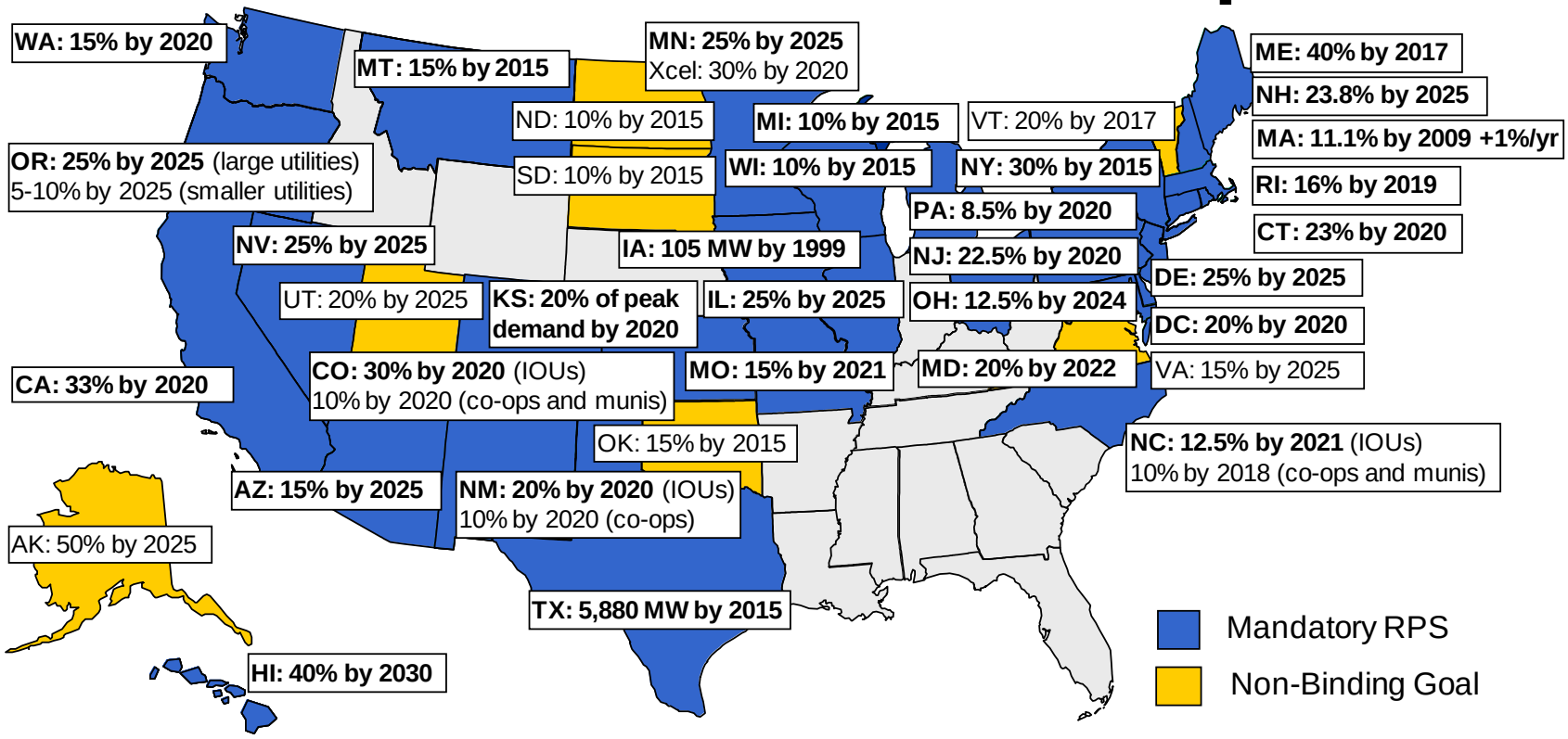
Note: Sample size is extremely limited

Policy and Market Drivers

Most Key Federal Incentives Are In Place Through the End of 2012

- The *Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010* (December 2010) extended the Section 1603 Treasury cash grant program by one year (projects must be under construction by the end of 2011 and online by the end of 2012 to be eligible)
  - More than 70% of the new wind capacity installed in 2010 elected the Section 1603 grant
- The same act increased first-year "bonus depreciation" to 100% through 2011, reverting back to 50% for 2012
- Commercial wind projects placed in service before the end of 2012 also have access to either the PTC or ITC (in lieu of the Section 1603 grant)
- The Section 1705 loan guarantee program is winding down, with a September 30, 2011 sunset date
- Significant federal policy uncertainty currently exists beyond 2012

State Policies Help Direct the Location and Amount of Wind Power Development



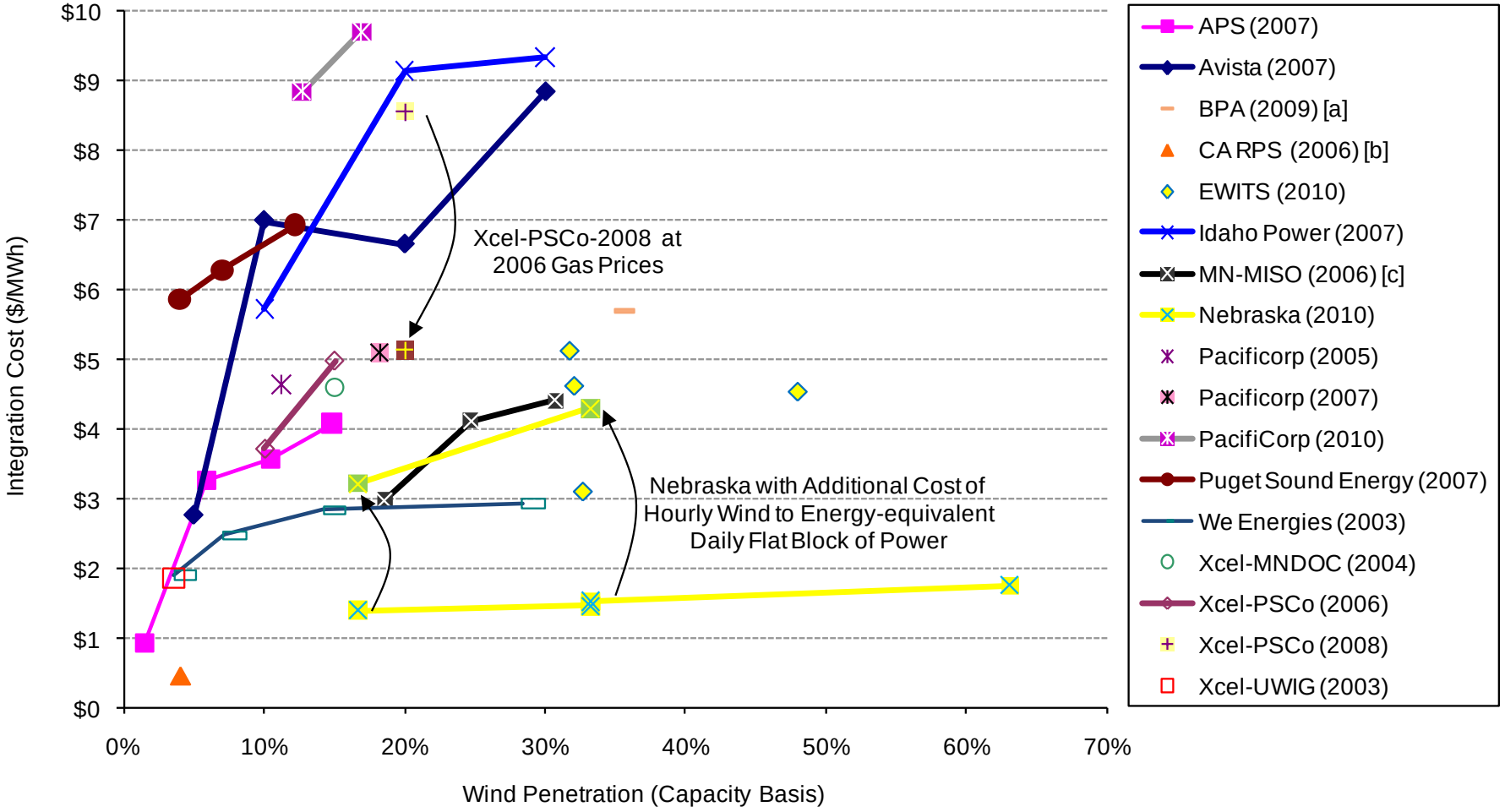
Source: Berkeley Lab

- 29 states and Washington, D.C. have mandatory RPS programs in place
- State renewable funds, tax incentives, utility resource planning, voluntary green power, and concerns about carbon emissions all also played a role in 2010

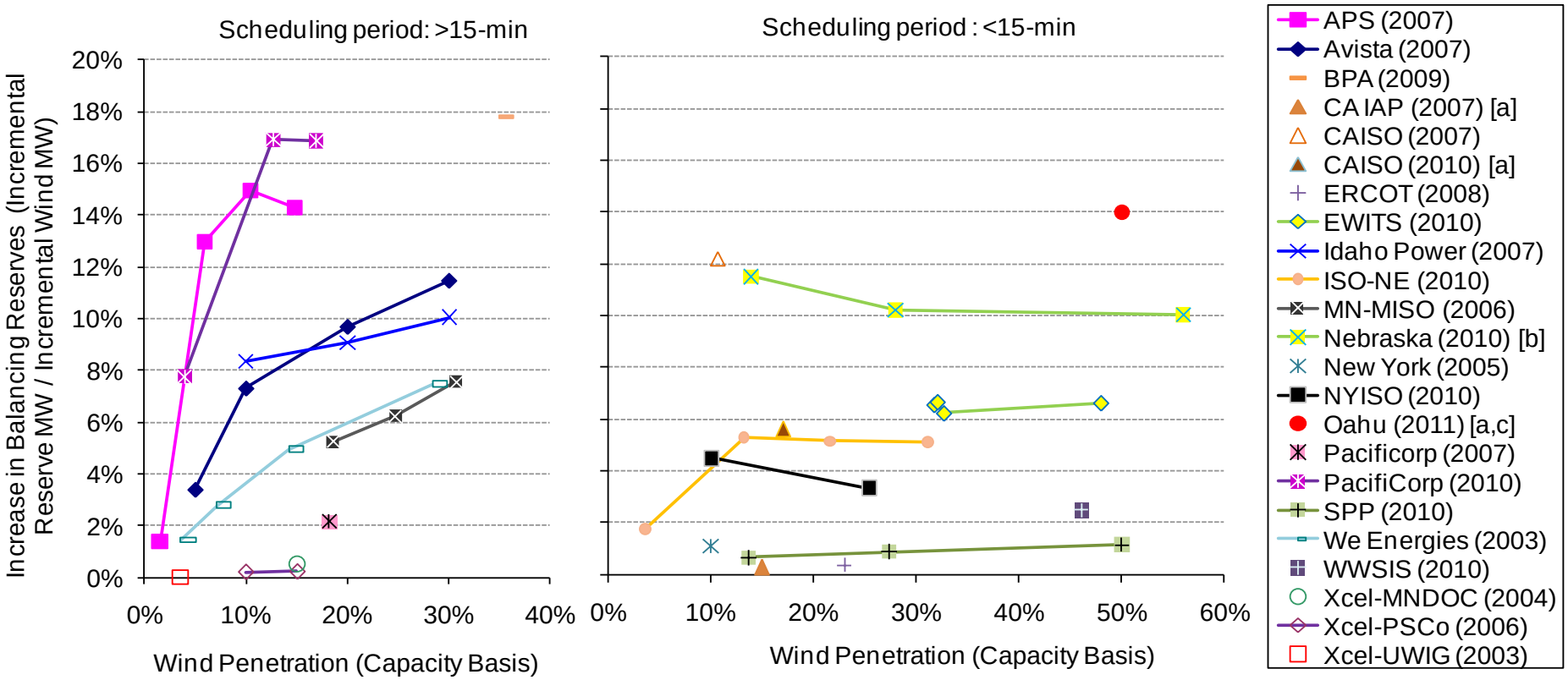
Despite Progress on Overcoming Transmission Barriers, Constraints Remain

- 8,800 circuit miles of new transmission added in 2010, but lack of transmission still a major barrier to wind development
- Cost allocation continues to be a major issue at FERC and among the ISOs/RTOs
- States, grid operators, regional organizations, and DOE continue to take proactive steps to encourage transmission investment to improve access to renewable resources
- Numerous transmission projects designed, in part, to support wind power made further progress in development and/or construction in 2010

Integrating Wind Energy into Power Systems Is Manageable, But Not Free of Costs



Studies Find that Greater Wind Penetration Requires Increased Balancing Reserves



- The increase in balancing reserves never exceeds 18% in these studies
- "Fast" markets (i.e., with shorter scheduling periods) can generally integrate wind more easily, with less need for increased balancing reserves (see graph on right)

Future Outlook

Most Forecasts Predict Modest Growth in 2011, With An Even Better 2012

- Projected growth based on rush to finish projects before key federal incentives expire at the end of 2012, improved project finance environment, lower wind turbine and wind power pricing
- Beyond 2012, federal policy uncertainty complicates forecasts
- U.S. expected to remain the 2nd-largest-market, after China, over this period

Source	2011	2012	2013	Cumulative Additions 2011-2013
EIA (2011)	4,450	7,480	170	12,100
BTM (2011)	8,000	10,000	8,000	26,000
IHS EER (2011)	5,700	6,100	6,300	18,100
Bloomberg NEF (2011)	7,300	7,800	7,700	22,800
MAKE Consulting (2011)	6,250	8,000	6,500	20,750
UBS Limited (2011)	5,400	5,600	5,900	16,900

Uncertainties in Near-Term Market Growth Reflect Conflicting Trends

Stronger Growth

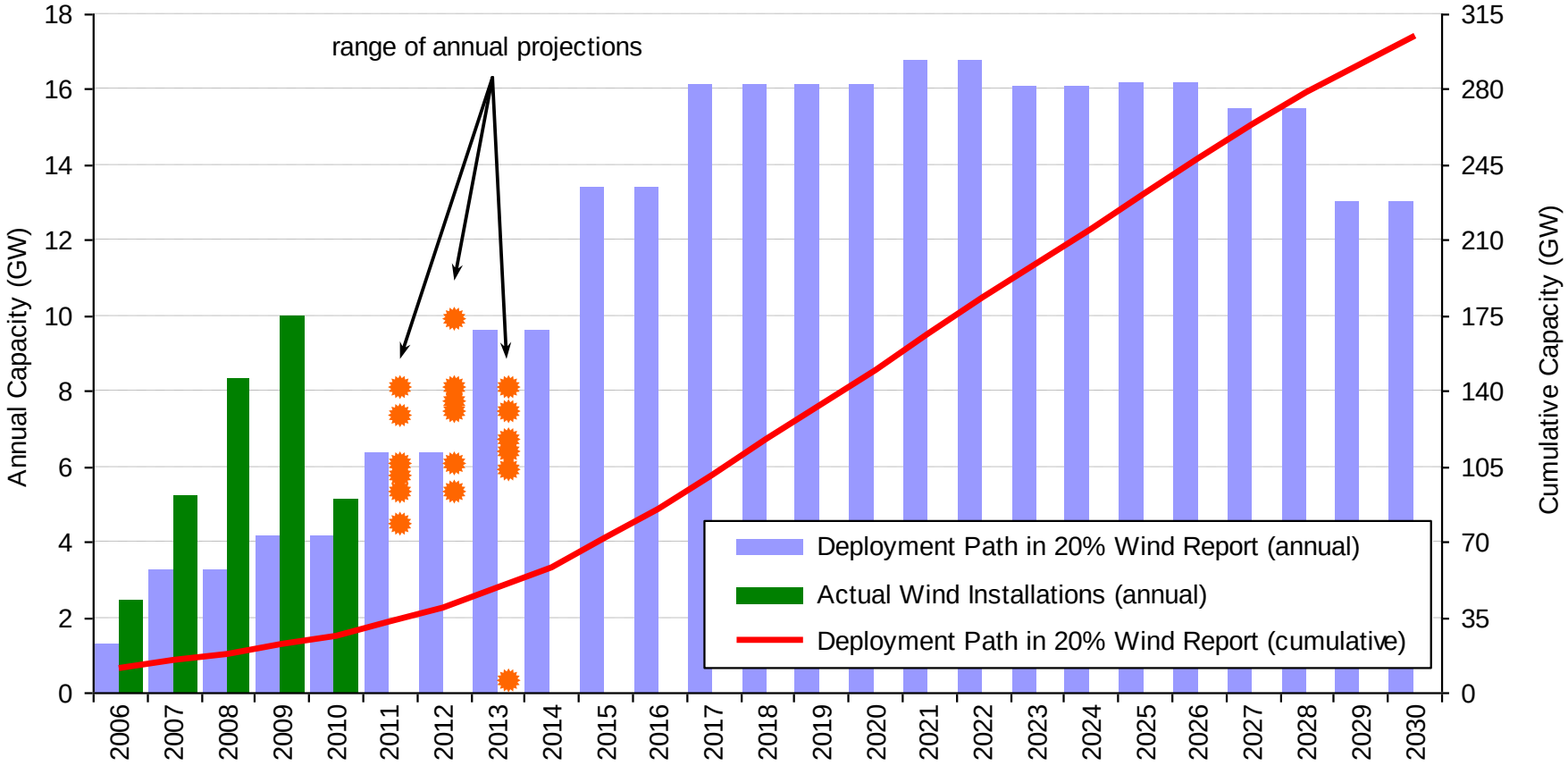
- Federal policy certainty through 2012 and increasingly aggressive state policies
- Improved financing conditions and availability of power purchase agreement
- Falling wind turbine prices resulting in improved comparative economics of wind energy

Weaker Growth

- Federal policy uncertainty leads to very uncertain prospects for 2013
- Limited need for new electric capacity additions to meet demand, and low natural gas and wholesale power prices
- Softer incremental demand from state RPS markets in near term due to over-build of wind in recent years
- Inadequate transmission infrastructure and siting/permitting procedures constrain/delay new builds
- Increased competition from solar energy in Southwest

U.S. Is on a Trajectory that May Lead to 20% of Electricity Coming from Wind

But ramping up further to ~16 GW/year and maintaining that pace for a decade is an enormous challenge, and is far from pre-determined



For More Information...

See full report for additional findings, a discussion of the sources of data used, etc.

- http://windandwater.energy.gov/

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